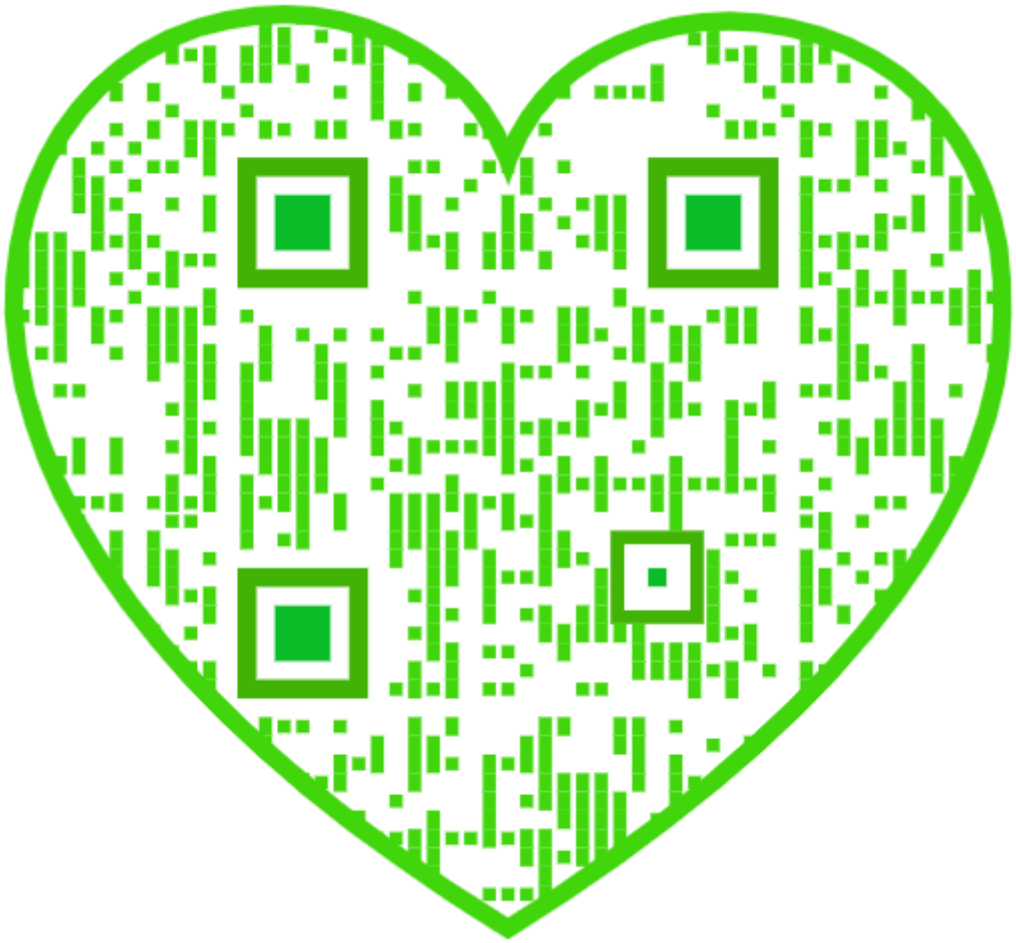

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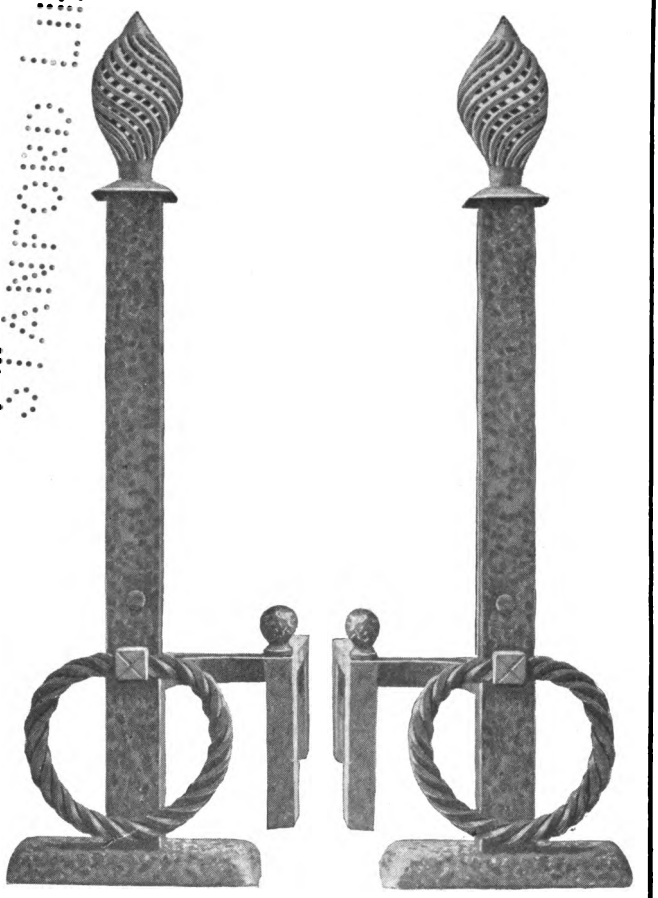

Hand-Wrought Andirons

HAND-FORGING

And Wrought-Iron Ornamental Work

By
THOMAS F. GOOGERTY

With Numerous Illustrations from Photographs and Drawings by the Author

CHICAGO: POPULAR MECHANICS COMPANY, PUBLISHERS

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Preface

REALIZING a demand for an inexpensive text-book on the subject of hand-wrought ornamental ironwork, this volume is offered to instructors in manual training, students, professional workers and others interested in this fascinating handicraft. While it deals largely with interior ironwork, it shows also the constructive principles of ornamental hand-forging and points out the guiding principles and methods which underlie all forge work.

That the amateur may more readily understand the principles involved, a number of designs and drawings, made by the author while teaching decorative ironwork, with instructions for working them out, have been incorporated in the text. These, it is hoped, will prove of value in stimulating original work. Most of the photographic reproductions contained in this volume represent specimens executed by pupils under the direction of

THE AUTHOR.

Pontiac, Illinois.

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Hand-Forging

CHAPTER I

INTRODUCTORY

EVERY man has an inborn love for the beautiful. Primitive man at first fashioned his utensils for purely utilitarian purposes, but as he became accustomed to their uses he became also dissatisfied with their rude appearance, and the spirit of decoration took possession of him. This is manifested in his early pottery and weapons of warfare. Through successive ages that instinctive love for decoration has manifested itself in all mankind.

Iron made the strongest gates, locks and hinges, and these were fashioned into many beautiful designs. Perhaps some of the finest examples of ornamental ironwork were made from the twelfth to the seventeenth century. Of late years iron has grown in favor and prestige, and it is now not only manufactured in artistic designs for architectural purposes, but many of our manual-training schools are producing excellent Art Craft ironwork. It has proven an acceptable departure from the ordinary ironwork heretofore taught and gives promise of ever in-

creasing popularity, for there is a fascination about it that appeals to both pupil and teacher.

Iron, as one of the baser metals, demands a close following of conventionalized treatment. Its forms should suggest combined strength and pliability, and it must be found in its proper place, serving the purpose for which it is made, and not overworked in such designs as leaves, twigs and flowers.

The wrought-iron worker should be intimately acquainted with his material. He must know how much working the metal will stand under certain conditions; how much can be worked hot and what part may be worked cold. He should be able to put his ideas on paper and picture their working-out in his mind. In no other way can one be successful in this craft. The true craftsman must study the ironwork of the past as well as modern examples in order to get a correct idea of what is considered good.

It is not the purpose of this volume to treat on design, for that is a study in itself. However, it may be well to say that designing in wrought iron, as in every other material, has limitations, and it should be kept free from impossible demands. Consideration must always be given to the appropriateness of the design as regards its position. In designing a set of andirons for a fireplace, for example, the first thing to consider

is the style and size of the fireplace. If this be built of brick or stone, iron is very appropriate. Andirons are a utilitarian device, and as such should be strong enough to resist the tendencies to bending or warping, due to the heat of the fire. Such ornamental features as are expressed in them should be a part of the necessities of their construction, rendered ornamental by simply twisting the bars into various shapes, or their treatment may depend on beauty of line and curve.

Every material has a character of its own, and the decoration best suited to it is the one that fully shows its character. Iron forms must show the resistant quality of that metal, and, whatever decoration is applied, the uses for which a piece of work is intended must not be interfered with by ornament. The design should grow out of structural necessities. The form must first be considered, then the decoration planned. Mere application of ornament to a utensil or surface is not decoration. It must be adapted or fitted as perfectly as possible, and by recognition of these demands it can be made harmonious.

In making designs for ironwork which consist of curve and scrollwork, there must be contrast and variety. These may be obtained by having a constant change in the curvature and direction of lines. If the design is for a grille, its shape

must be taken into consideration. If the grille is oblong, the design may repeat itself on each side of a center line. The leading lines of the design may then start from this center, and their direction should emphasize the lines of its bound-

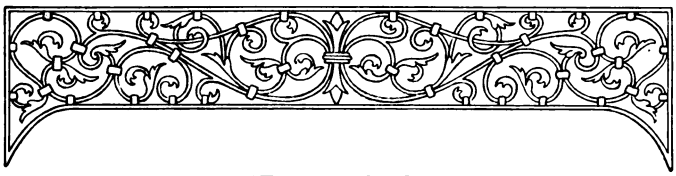


Fig. 1. Grille

ary. These lines are the first to be planned and placed into position; next the secondary lines are planned. These should also be influenced in their direction by the main lines.

Another point to take into consideration is the distribution of lines, that there may be a regulated balance between the lines and masses into which they divide. (See Fig. 1, an interior grille which represents repetition, contrast and variety.)

A little study of linear ornament and such geometrical figures as the circle, oval and spiral will be of assistance to the worker in designing this class of scrollwork. The circle in itself has not the interest that the oval or the spiral has, owing to its curve being the same through its entire length, while the oval and spiral have a constant change

of curve and direction in their lines, giving them a variety which the circle does not afford.

The spiral is an important element in the designing of ironwork. It may be closely coiled in order to give it the appearance of strength and resistance, or the coil may be loose, to suggest lightness and grace.

These geometrical forms will yield curves of great decorative value to the designer of ironwork. By using portions of their curves and combining them with one another and with straight lines, the result will be a variety of lines which may be used in the formation of rich patterns.

Note the curves combined in Fig. 2. At A two spirals of different size are connected with a portion of the curve of the oval. The fusion of lines is so complete that it is difficult to determine the

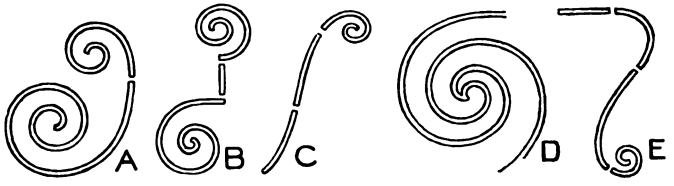


Fig. 2. Curve Combinations

juncture of lines. At B are shown two spirals connected with a straight line; at C, the curves of the oval with the spiral. At D are two spirals unwinding from a common center. This form may often be used to advantage in designing ironwork.

At E we have combined the straight line with the curve of the circle, the oval and the spiral. These examples of simple curves are given here to show that they may be combined to form lines that will be of value in design. The curves of the ellipse

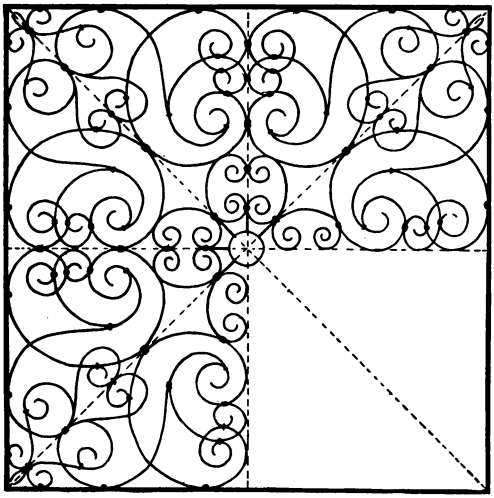


Fig. 3. Laying Out a Design.

and parabola may also be used to great advantage in the formation of these curves.

In Fig. 3 we have a method of laying out a design which repeats on each side of a diagonal line and which consists of an arrangement of eight equal triangles. This design is made up of curves of the geometrical forms mentioned above, ar-

ranged to fit one of the triangles and then repeated through the entire square. The design would be suitable for a square window grille and may be made of flat iron riveted together, with the frame of thicker stock.

Rules without number have been rehearsed through countless printed pages on the subject of design. One who wishes to understand must study the principles. He must study historic art in order to find what is good, and why. He must also study nature for the inspiration that will enable him to invent ornaments of real interest.

CHAPTER II

EQUIPMENT

THE equipment necessary for forging ornamental ironwork is nothing more than the ordinary forge-shop and tools. A few special tools will be needed in working out some of the exercises, but they can be made by hand with little expense. These will be taken up later on.

The Forge.—One of the indispensable things in doing any kind of forging is a good forge. Its size depends on the kind of work to be done. For heavy work, a large forge or furnace is necessary; for doing light or medium work, and for working out the designs given in this book, a down-draft forge like those used in all manual-training schools is adequate.

Fuel.—The fuel to be used for heating purposes is coal. This should be the best of soft coal and free from impurities if possible. Sulphur is one of the common impurities. It is difficult to get a welding heat in a fire that contains sulphur. Slate should also be avoided, as it causes clinkers and prevents proper heating of the iron. Coal should always be procured, if possible, direct from the mines, as coal which has been long in the yard in large cities is not so good. Good coal will be bright and clean in appearance, without dark

streaks. It should readily break into small pieces when given a blow with a hammer. It should always be thoroughly soaked with water before it is put on the fire. This helps to keep the fire confined to a center, and also causes the coal to coke better.

The Fire.—To build a fire all the clinkers should be cleaned out down to the tuyere. Some shavings are then placed over the tuyere and lighted. After they are well burned a little coke is placed on, and the fire is then given a little blast. Wet coal should be placed at the sides of the fire, letting it come to the top in a mound shape. The fire should be kept open at the top and front with the poker and not allowed to break out at the sides. poker and not allowed to break out at the sides. well coked the blast is shut off, and the fire is then in good shape for heating. There should always be some extra coke on the forge. As the center of the fire burns out it may be replenished with the extra coke, especially when welding. Wet coal must never be put on top of the fire. As the center burns out and the fire spreads the coal is put on the sides; at the same time it is tamped down with the end of a shovel, moving the well-burned sides toward the center, thereby filling the burned-out center with fresh coke.

The secret of doing good forging lies in keeping a good fire, built in the proper shape to suit the

work being done. This comes only by experience. Men who have worked for years at forging and are successful in this line of work pay particular attention to their fire; they know that to do work fast and well they must have a good fire. Younger men who are working at forging cannot be urged too strongly to pay particular attention to their fire. It should always be clean, and clinkers should be picked out with the poker. The fine cinders may be dropped below by pulling the slide at the bottom of the tuyere, but the fire must not be torn to pieces when cleaning, as this is not necessary.

Heating.—It is not advisable to turn on too much blast at first in heating, especially when welding. Heat slowly until the iron becomes quite hot; then it may be given more blast. Large pieces of iron that are heated too quickly get hot on the outside while the center is not so hot. Heating slowly will get the piece hot throughout. Then, again, too much blast is liable to come in contact with the piece being heated and cool it. This generally comes from putting the piece down too low in the fire, or it may come from having a hollow fire,with not enough coke under the iron. This kind of a fire may be helped by forcing the sides in toward the center with the shovel, then putting more coal on. However, too strong a blast is liable to burn the coke before the heat is

raised. The proper handling of the fire will come by experience if these suggestions are followed.

Materials.—The materials used in forging are iron, soft steel and tool steel. Where there is a great deal of welding to be done it is advisable to use iron. In the formation of scrollwork and all parts not to be welded, soft steel is best, as it will stand the strain in working better than iron. For embossed work sheet steel is best—deep stamping steel. Norway iron may be used in some cases. It is not the purpose of this volume to give the method of manufacturing the various kinds of material in use, as this knowledge is not essential to one working out the examples given later, and it is thought better to devote the space to them.

Wrought Iron.—Swedish iron is considered the best iron for forging. This is because the ore and the process used in manufacturing it are superior. It will readily bend cold to any angle without danger of cracking, and it may be forged in many difficult shapes while hot. The common wrought iron, however, is used more generally in forging than the Swedish, on account of its cheapness, and for nearly all kinds of work it is good enough. Iron may be readily distinguished when broken, its grain presenting a fibrous appearance with little dark streaks running lengthwise through the bar. These dark streaks are what is known as slag. Iron contains very little if any carbon.

The carbon being extracted makes the metal malleable and soft and so that it cannot be hardened by heating and cooling in water as steel can.

Mild Steel.—The structure of mild steel is similar to wrought iron. In steel the grain is bright and crystalline in appearance, while in iron it is fibrous. Soft steel contains a little more carbon than iron, making it a little harder to weld, and it must not be heated so hot. It will readily bend in any shape while hot without danger of breaking. Mild steel should be used when there is considerable bending or forging to be done.

Tool Steel is used to make the various tools used in the shop, such as chisels, drills, punches, etc. It varies in hardness according to the amount of carbon it contains. The more carbon it contains, the harder fire and water will make it. It should never be heated as hot as iron or soft steel, as it will burn in the fire, or, if struck a blow with a hammer, it would fly to pieces. It can be welded if it does not contain too much carbon, and most tool steel may be welded, if handled carefully, by using a flux, such as borax, or some other welding compound. It is hardened or tempered by heating it to a dull red and quenching it in water or oil. As an example, to temper a cold chisel, heat it with a slow heat to a dark red, say for $1\frac{1}{2}$ in. on the cutting end; then cool it in water by dipping it for an inch, remove it, and with a piece of

sandpaper rub its cutting edge bright. The heat that remains in the chisel will run to the cutting edge, starting with a yellow color and gradually turning the bright steel to a very dark blue. Then it should be cooled in water. If the chisel, when

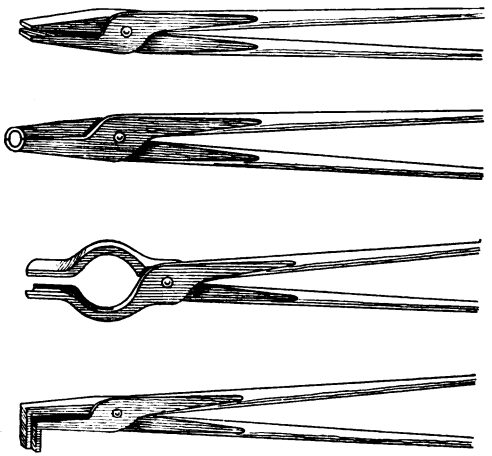


Fig. 4. Various Forms of Tongs

put to use, is found to be too hard or soft, repeat the tempering process. If too hard, let the color become more dark as it runs out. If too soft, a little lighter. A little experience will help one to determine the proper color, especially if one brand of steel is used.

In quenching hot steel to be hardened in water, the degree of heat should be no higher than that at which the steel will harden. It must be an

even heat—hot throughout the piece. It must not be quenched in water that is too cold, as there is danger of cracking the steel from uneven heating and cold water. A little salt in the water makes a good quenching bath.

Tools.—It is necessary to have a fair knowledge of an ordinary forge-shop and the tools in use. There should be a good set of tongs of all kinds, such as flat and round jaws, as shown in Fig. 4. The jaws should be forged from square Swedish iron or soft steel. For small tongs ½-in. square is about right; others may be forged from ⅝-in., ¾-in., ⅞-in. and 1-in. The reins, or handles, may be common iron from ¼ in. round to $\frac{5}{16}$ or ⅜ in., and $\frac{7}{16}$ in. for the larger ones. The handles should be well thickened, or upset, on one end, for a distance of 2 in., and welded to the different-sized jaws. Tongs should be forged neatly and well fitted in the jaws. The rivet in the jaws should be a piece of round iron cut long enough to head from each side. After the jaws are forged and the reins welded, the hole is punched in one jaw for the rivet. Then the other jaw is heated. It is then laid on the anvil, and, setting the piece that is punched on top of it, it is marked and the hole punched. The piece that is to be used as a rivet is heated, and, placing the two jaws together on the anvil, the rivet is inserted into the holes and headed from both sides, riveting the jaws tightly

together and finishing with a round head, or as nearly round as can be done with a hand hammer. The tongs are then placed in the fire, and when heated, a rein is grasped in each hand, working them back and forth until they work freely on

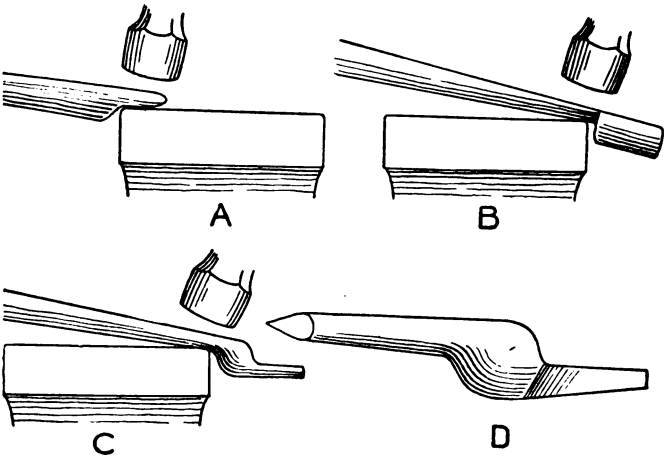


Fig. 5. Method of Forging Tongs

the rivet. Rivets in larger tongs should be of $\frac{5}{16}$-in., $\frac{3}{8}$-in. or $\frac{7}{16}$-in. stock, according to the kind and size of tongs. Stock rivets with a head on one end should not be used, as the tongs will not hold so well nor look so neat. Tongs should not be filed unless in corners of jaws to make them fit. Some smiths never use a file on tongs. They are supposed to be forged and not filed, and so they should be seen as forged work.

To forge a pair of tongs from ¾-in. square Swedish iron, the bar is heated and about 1⅛ in. is set on the inner edge of the anvil, keeping the bar at right angles to the long way of anvil. It is then flattened to about $\frac{7}{16}$ in. thick, letting it taper near the end. This will form the flat part of the jaw. See Fig. 5, at A. The bar is next turned one-quarter over, set on the outer edge of the anvil and flattened as at B. It is again turned and hammered as at C. The jaw is now cut from the bar with a hot chisel, leaving a shank long enough so that a handle can be welded to it. This shank should be drawn out to the proper size and scarfed. It should now look as at D,

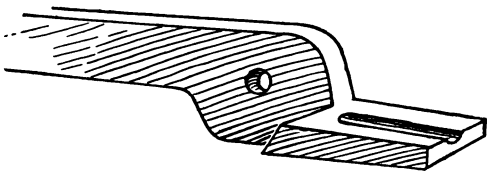


Fig. 6. Jaw with Fuller Mark

ready to be welded to the handle. In forging the jaw as explained above there should be a welding heat taken on the bar, and when hammering a helper should strike it with a sledge. The entire jaw should be made with this heat. If there is no helper, of course, more than one heat is neces-

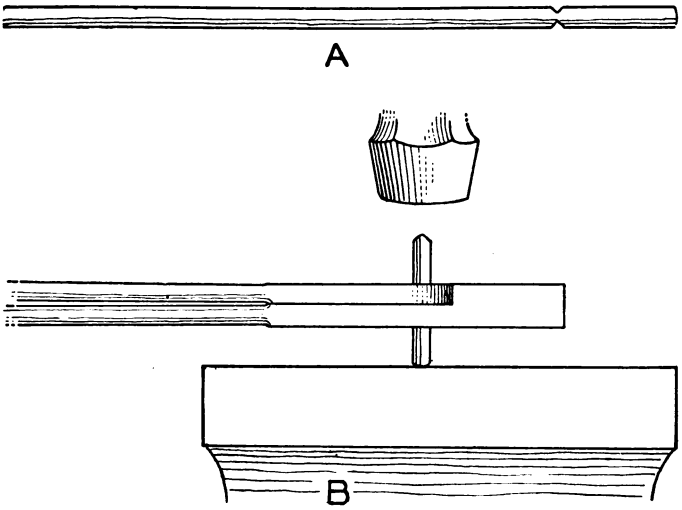


Fig. 7. Making a Rivet for the Tongs

sary. A piece of ⅜-in. round iron 17 in. long for a handle is now upset considerably at one end and at the same time scarfed. A welding heat is taken on the jaw and handle, welding the two together and swaging the edges with a ⅜-in. swage to smooth them. The jaw may now be shaped up and a ⅜-in. hole punched for the rivet.

Fig. 8. Binding the Tongs with a Ring

The flat part of the jaw is also fullered lengthwise with a small fuller. The fuller mark is to help hold flat and round bars when in the tongs. (See Fig. 6.) The tong handles are heated and hammered smooth at their ends so that they will not injure the hands. After the holes are punched, a piece of $\frac{3}{8}$-in. round iron is heated at one end and enough stock partly cut off to make a rivet as shown at A, Fig. 7. This piece is again heated and the two jaws of tongs set together on the anvil, the rivet is inserted into the holes, and the bar broken off at the cut previously made. The rivet is now hammered on both ends to head it, as shown at B. The rivet should be drawn tight with the hammer. Afterward the jaws are heated red and the handles worked back and forth until they are free on the rivet.

Tongs may also be made by forging them under a steam hammer, making the jaws and handles from one piece of stock without any welding, but as the object is to teach the pupil to become familiar with his tools and materials, this method is not to be recommended in manual-training forge-shops.

In forging light pieces that have to be held with tongs, always use a light pair that fits the piece well. It is also convenient to place a ring on the end of the reins to bind them firmly to the piece being forged. They can thus be more easily

handled. (See Fig. 8.) A large pair of tongs should never be used on small work, as they are clumsy and awkward to handle. Tongs must be kept in good repair and always in their rack. There will be less trouble in doing work if this is done.

There should be a full set of anvil tools, such as swages of all kinds (see Figs. 9 and 10) and a couple of set hammers forged from 1¼-in. square tool steel. One of these set hammers should have the edges of the face rounded just a little so as not to cut the iron and start a crack when using it; the other may be square on the face. There should be two flatters, one light and the other a little heavier; one or two cold chisels, one large and one small, forged from 1¼-in. and 1½-in. square tool steel; three or four hot chisels forged from 1⅛-in. and larger tool steel; also top and bottom fullers of various sizes. The eyes in the above tools should not be drilled, but punched while the piece is hot. The eye must not be punched too large: it should be small with a good deal of stock on each side of it to guard against breaking. A hickory buggy-spoke makes a good handle. It should not be wedged in this kind of a tool, but should fit the eye nicely and stick through about an inch. Then there is no danger of the tool being knocked off the handle from the blows of the sledge, as it can be seen

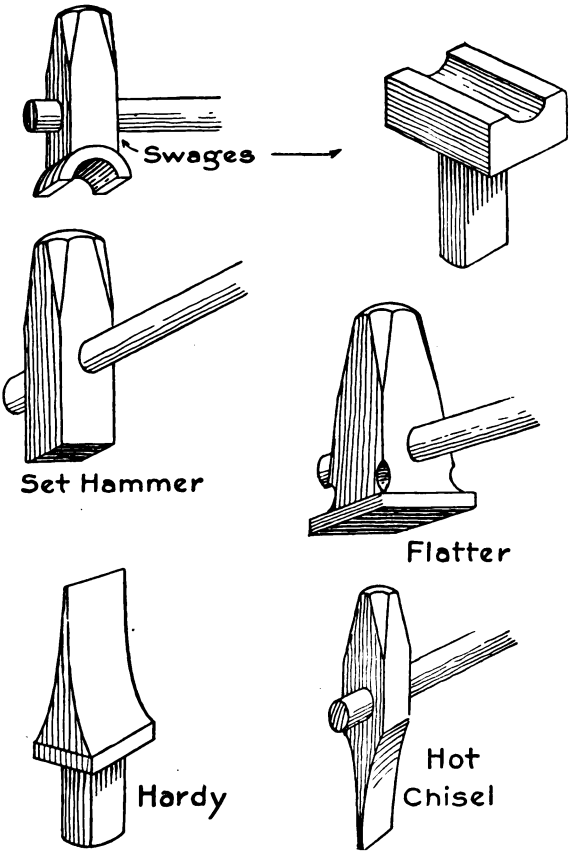


Fig. 9. Anvil Tools. I

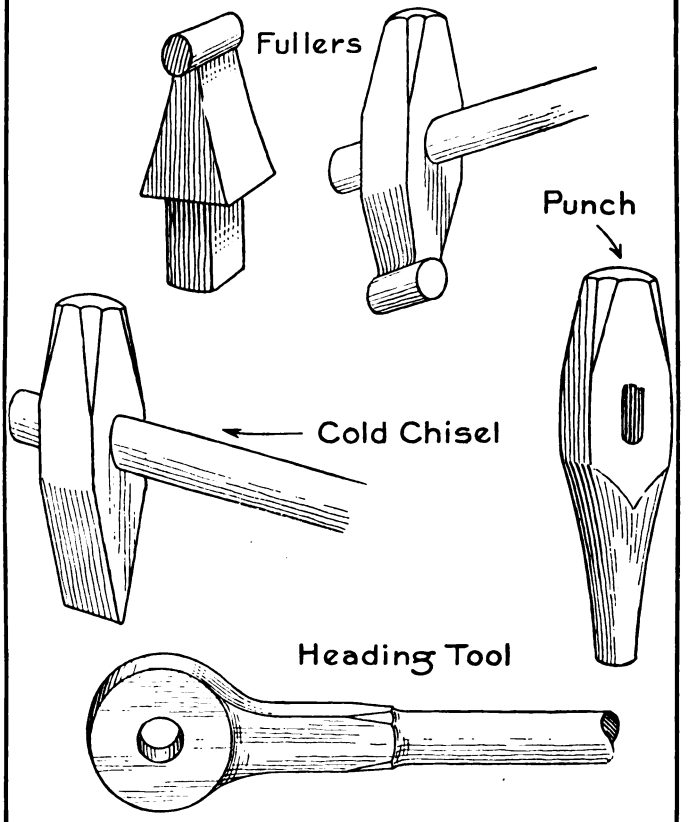


Fig. 10. Anvil Tools. II

working toward the end of the handle before it jumps off.

There should be three ball-peen hand hammers for forging, weighing 1 lb., 1½ lb. and 2 lb., respectively; also two hardies to fit the square holes in the anvil, forged from 1¼-in. square tool steel, one for cutting cold iron and the other, a little thinner, for cutting hot iron. There must be a few square and round hand punches made from ⅝-in. and ¾-in. tool steel, drawn out tapering, and some long, thin hot chisels 12 in. long made from ⅝-in. and ¾-in. hexagon tool steel, to be used for chipping off pieces from hot iron. When in need of special tools they should be made and a place provided in which to keep them.

Tools that are to be struck on with a sledge should not be forged too heavy. It takes a much harder blow on a heavy tool than on a lighter one. Then, too, light tools can be handled more quickly, and the work can be finished with them better and easier.

All kinds of forgings should first be hammered with the hand hammer and sledge when possible. Anvil tools should not be used to draw out stock by striking on them with a sledge, for this wears out the tools, and the same work can be done as well with sledge and hammer. Tools of this kind are used only to smooth and finish work. Occasionally it may be necessary to use them in

drawing, in places where the sledge is liable to injure the work. When finishing a forging of any kind, work it down smooth with a black heat and light blows of the hammer. Knock

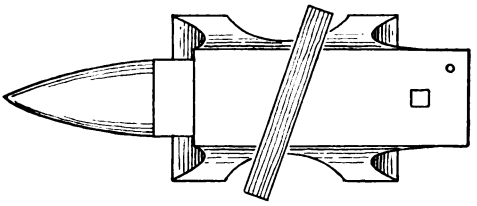


Fig. 11. The Wrong Way to Draw a Piece of Iron

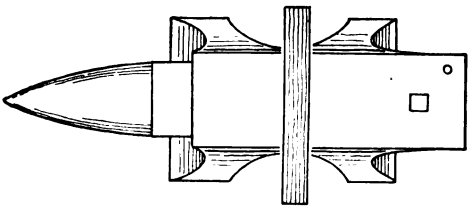


Fig. 12. The Right Way

off all the scales and dirt. If it cannot be hammered off, scrape it off with an old file. This makes the work look better.

The anvil, when new, is a little rounded on top across the face, and it is made high in the center to resist the strain from the blows of the hammer and sledge. As the anvil becomes old this high

place gradually becomes lower, and finally there is a slight hollow where it receives the most blows. In drawing out stock these high and low places in anvils must be considered; for instance, in drawing a piece that must be kept straight and square, it must be placed on the anvil straight across its face, or at right angles to the length. If held at an angle the piece will become winding. (See Fig. 11, the wrong way; then see Fig. 12, the correct way in drawing.) This will be readily understood when you consider that the anvil is high or low. That part of the anvil nearest the horn, not being used so much in forging, is generally a good place to smooth up a piece with a flatter when giving it a final finish.

When drawing iron, always raise the piece to a welding heat. This welds any fracture that may be in the piece and also refines the iron, while drawing without a welding heat is liable to fracture the grain so it will split open. Then, too, a large piece of iron must receive heavy blows in order to draw it in the center of the piece. Light blows have a tendency to draw on the outer edge and not throughout the piece as they should. Therefore it must be brought to a welding heat when drawing. It must also be kept in shape while drawing and not allowed to become twisted.

CHAPTER III

WORKING AT THE FORGE

BY upsetting is meant the thickening or shortening of a piece of iron or steel. In upsetting stock the heat should be taken just where it needs to be made large. In case the heat spreads over more of the bar than is desired, water should be poured on the part which is to be cooled. There

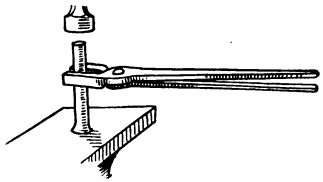


Fig. 13. One Method of Upsetting

are different methods of upsetting. Say, for instance, a bar 10 in. long is to be upset on the end. It is heated on that end, then caught in a pair of tongs, holding the piece vertical, and hammered on the cold end while the hot end is on the anvil. This hammering bulges the iron out where it is hot. The piece should be kept straight while upsetting, as it upsets much faster and is not so liable to fracture the grain of the stock. (See drawing, Fig. 13.)

Another method of upsetting is shown in Fig. 14. The piece is held in the tongs, and the metal is driven back with the hand hammer. This method is a good one when the piece needs but little

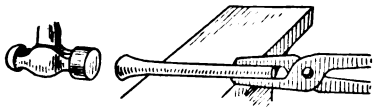


Fig. 14. Another Method of Upsetting

enlarging. For instance, where small stock is to be welded together, it is quicker and easier to keep the bar straight, as the tongs need not be changed; at the same time the scarf can be partly worked out.

Ramming.—When bars from 2 ft. to 4 or 5 ft. long are to be upset they are heated on the end and churned up and down on the anvil, the force of the blow enlarging the part heated. Or, in case the bar is to be upset a foot from one end, the bar being long enough to be handled without danger of burning the hands, it is upset by ramming. (See Fig. 15.)

Another way of upsetting pieces that cannot be rammed or upset on the anvil, owing to parts that must not be hammered on, is to heat the part to be upset in the same manner as described above, then catching it in a strong vise and en-

larging the part by striking it with a hand hammer.

Punching.—Holes may be punched while the iron is hot or when cold. It depends on the size of stock and the facilities at hand for doing the work. Heavy stock is punched while the iron is hot, using a sledge hammer and a punch with a handle in it. Light punching may be done with

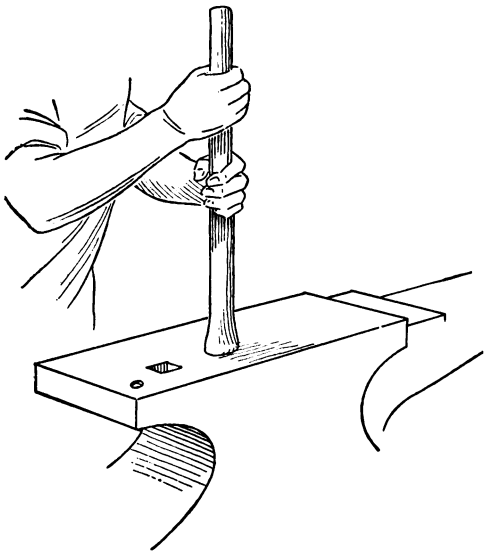


Fig. 15. Upsetting by Ramming

the hand hammer and a hand punch. In punching while the iron is hot, the piece is taken to the anvil and the punch set on the part that is to have the hole; it is then given a few sharp blows

with the hammer, driving the punch into the metal as far as it will go. The piece is then turned over, and a dark spot will be seen directly over the depression made by the punch. The punch

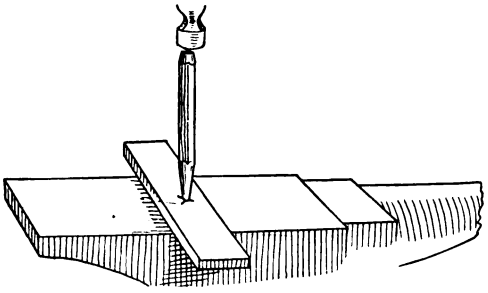


Fig. 16. Punching

is then set on this spot and given a few more blows with the hammer. (See Figs. 16 and 17.) The piece is now moved directly over the round

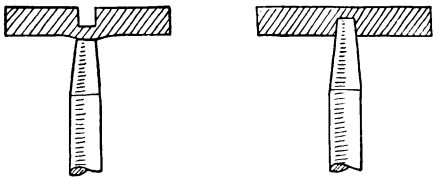


Fig. 17. Completing the Punch Hole

hole in the anvil and given a few blows with the hammer, driving out the burr. The hole is made as large as needed by driving the punch farther in. In punching heavy stock, it is necessary to cool

the punch in water once in a while, as it is liable to bend from the heat of the iron.

Light stock may be punched cold. In doing this the punch is the same size as the hole needed. It is better to use a short, thick, slightly tempered punch, which is not so liable to bend. In cold punching there is also used a punch block, which is a small, round or square block of iron with a steel face welded on it. The block may have different-sized holes in it. The holes are tapered,

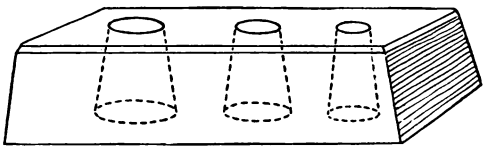


Fig. 18. Punch Block

being larger at the bottom to let the burr from the punch drop out. The block should also be hardened to protect the face from damage while punching. (See Fig. 18.)

In cold punching, the piece that is to have the hole is set on the block directly over the hole in the punch block. A little oil is now rubbed on the punch, and it is set on the piece over the hole; with the hammer it is given one or two hard blows, driving the punch through the metal, at the same time cutting out a piece just the size of the hole in the block.

Bending.—Iron or soft steel may be bent to almost any angle while hot, and many kinds while cold. In cold bending the size and kind of stock must be considered. If the pieces are round or

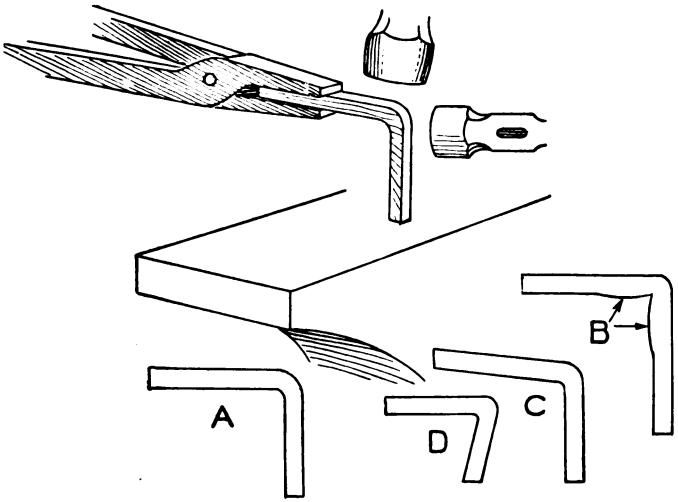


Fig. 19. Working a Square Corner

rectangular in shape and of light weight they may be bent while cold, especially if the stock is soft steel. A light bar of soft steel may be caught in a vise and bent at right angles by striking it with a hammer. If iron is used, curved forms are more readily bent than angles, as iron will not stand the strains due to bending like soft steel will. In bending a heavy bar it must be heated.

It may then be caught in a vise and bent at right angles, or it may be bent over the edge of the anvil. If the corner of an angle is to be a square one it must not be bent in a vise, as the jaws of the vise are liable to fracture the grain. Another reason is that the inner corner of the angle is made sharp by the jaws of the vise, and any working it receives afterward in making the corner square will cause it to crack. Perhaps the best method of working a square corner is to heat the bar at the place it is to be bent and bend it nearly at right angles over the edge of the anvil, leaving the corner round as shown in Fig. 19 at A. The corner is then heated and worked square by hammering it on the outside of corner as shown in the drawing. The corner must not be hammered while the piece is square, but must be kept at the angle shown at C. The reason for this is that the blows of the hammer must upset the outer corner. If it is hammered while the piece is in the shape shown at D, the inner corner will upset and form a crack. It must therefore be kept at the angle as shown at C and not allowed to get out of shape while upsetting. If a crack should start to form at the inner corner by this method of hammering, which is sometimes the case, it must then be drawn out by hammering each side of the crack as shown by the arrows at B. This hammering will draw the metal away from the crack,

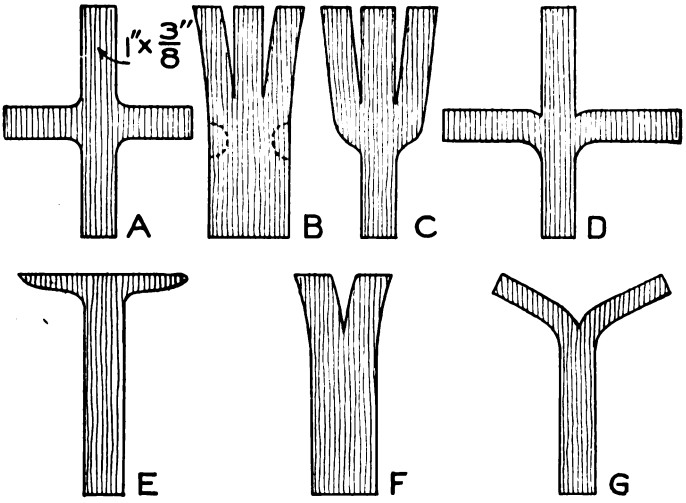


Fig. 20. Solid Forgings

while hammering on the opposite side will force the crack deeper into the corner. After the corner is worked square it should be flatted smooth. Another method in working a square corner is to upset the bar considerably and then bend the angle and work up the corner in the manner described above. Perhaps this is the safest method, although it takes more time.

Solid Forgings.—A solid forging is one that is forged from one piece of stock, as, for instance, a form like the one shown in Fig. 20 at A. This piece can be made with a cross weld by using 1x3/8-in. stock, but if it is to be forged from one

piece the stock should be about 3¼ in. wide by ⅜ in. thick. The method in forging this piece is first to split the bar with a thin hot chisel as shown at B. It is then fullered about 1 in. below the split part and drawn out, or the extra stock cut off, as at C. The piece is next heated and the outside is spread as at D. It is then finished to size. Another form of solid forging is shown at E. The piece is split and fullered as at F, the bottom part is drawn out, and the split ends hammered as shown at G. It is then heated and worked into shape with the hand hammer.

Shrinking Bands.—If a band of iron is heated, its circumference will expand. If it is then

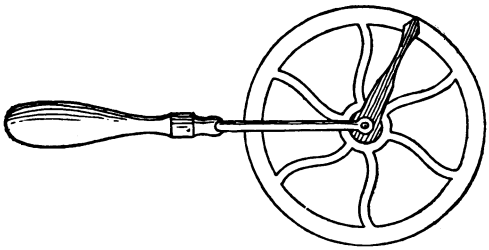


Fig. 21. Traveler, or Tire-Measuring Wheel

driven onto a piece of round iron and cooled with water, it will shrink to its original size and become tight. The method of shrinking on bands is first to find their length. This may be done by measuring with a string around the piece that is to

receive the band, allowing for the weld. The stock is then cut and the band formed and welded, after which it is heated red, driven in place and cooled with water. If the band be a large one, the stock is cut so as to allow a little more than is needed. It is then formed cold by hand or in rollers. The part that is to receive the band is run on the outside with a tire-measuring wheel or traveler as shown in Fig. 21, noting the number of revolutions of the traveler; the band is then run on the inside with the traveler, stopping when the indicator or hand registers the same number of revolutions; the extra stock is cut off, and the band welded. It is then heated and driven in place.

CHAPTER IV

WELDING

IF two pieces of iron are brought to a white heat, or to a heat just before the iron burns in a fire, and are then placed on an anvil and hammered, the two will unite and form one piece. This is called welding. Good welding requires a great deal of practical experience. Some never become proficient at welding, and the best smiths fail at times, while others weld with the greatest ease, apparently without effort.

The secret in getting the right heat and making a good weld is: First, the fire must be clean and built to suit the pieces being welded. Second, the scarfs must be prepared in the proper manner, just the right length. When lapped they must not cover one another too much nor too little, and when being welded they must be hammered in the right place at the right time.

The suggestions offered here are simply to give an idea how the work is done. Only by practical experience can welding be learned, just as practice alone will enable one to see the right heat in the fire. It is the purpose of this chapter to explain and illustrate welding as it occurs to the

workman, based on practical experience. Tool-steel welding will not be taken up here, only iron and soft steel being considered, because these are in constant use in blacksmithing. As illustrations specific cases will be taken, but it must be borne in mind that the principles involved are the same in all welding.

If a piece of iron is heated in a fire which is too hollow, allowing the air to come in contact with it, the iron will scale or oxidize. No matter how hot it becomes, it cannot be welded while this scale is present. The oxidization is caused by not having a fire with enough coke under the iron, or a fire which is not clean. There must be plenty of coke under the piece so that all the oxygen is consumed in the combustion. If more air is used than the fire can take care of, the surplus will come in contact with the piece being heated and cause oxidization. Therefore the blast should be regulated to suit the fire.

Iron can be welded without using any flux. However, in some cases a good, clean, sharp sand should be used, because this forms a fusible mixture or slag which offers a protection to the iron, excluding the air and also tending to promote an even heat. Borax should be used on iron *only* in welding very small pieces.

Some soft steel can be welded without using a flux, but it is always advisable to use one

of some kind, such as sand. A good flux for soft steel is made by heating a piece of white marble red, letting it cool and pounding it fine with a hammer. This is used in the same manner as sand. Any of the welding compounds offered to

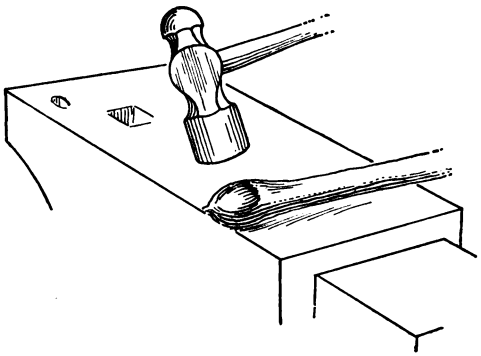


Fig. 22. Scarfing

the trade by dealers may be used to advantage in making some forms of welds.

There are many kinds of welding in use, depending on the strain they have to resist and the equipment for making them. Following are some of the common kinds which will be described in detail: Scarf weld, corner weld, T weld, split weld, jump weld and lap weld.

Scarf Welding.—This kind of welding requires a fire with a good bank of coal on the sides and back, well rounded up. There should be plenty

of well burned coke on the forge to be used in taking the heat. For example, to weld two pieces of 1-in. round iron, the pieces should be upset on the ends and scarfed by hammering them back with the hand hammer, as shown in Fig. 22. The piece is then turned over onto the side of anvil and

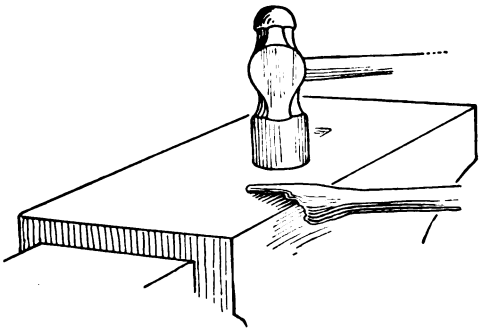


Fig. 23. Hammering the Steps

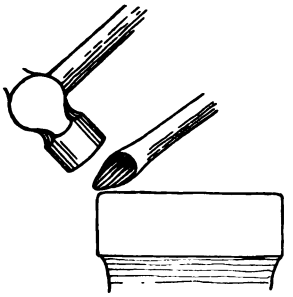


Fig. 24. Drawing to a Point

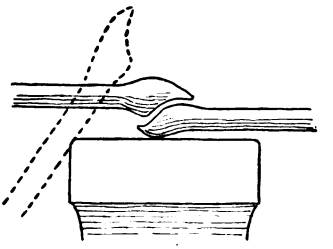


Fig. 25. Laying Heated Ends Together

hammered down with a series of steps, as shown in Fig. 23, after which it is turned on its side and drawn to a point, as shown in Fig. 24. When both are scarfed, they are placed in the fire with the laps down and raised to the welding heat. The smith takes both pieces out onto the anvil at

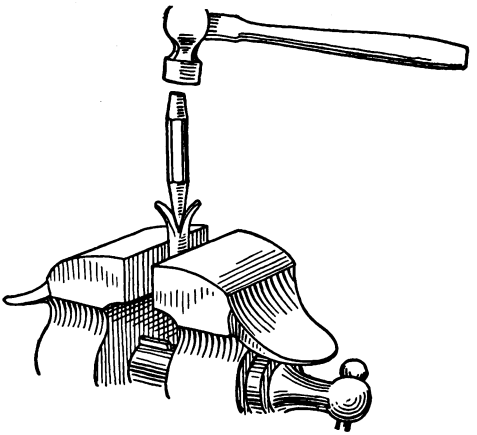


Fig. 26. Splitting the End

the same time, giving them a rap in order to knock off any foreign matter that might be on the scarfs. The piece in the right hand is set directly on the center of the anvil with the lap up. The piece in the left hand is placed against the inside edge of the anvil, as shown by the dotted lines in Fig. 25. The hand is then raised, teetering the piece on top of the one under it. The smith then lets go of the piece in the right hand and with the hand

hammer taps gently until the pieces are stuck, then hammering them together with quick, hard licks, or with the help of a striker. The weld may now be finished by hammering, or with swages. This kind of welding should be made with one heat. In fact nearly all good welding is made in one

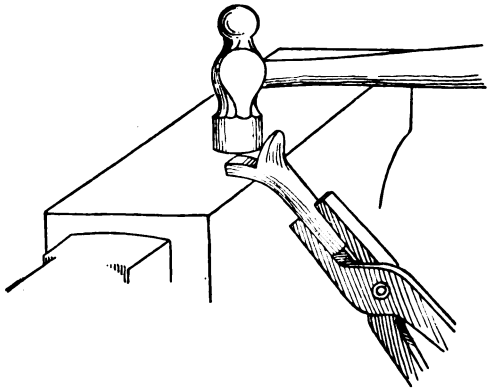


Fig. 27. Forming Scarfs to Fit Bar

heat. The practice of sticking pieces together and then placing them back in the fire for the welding heat is wrong.

Lap Welding.—Small work, such as $\frac{1}{16}$ to $\frac{1}{8}$ in. thick and in width $\frac{3}{8}$ in. or more, should always be welded with separate heats. Very thin stock, either soft steel or iron, may be welded without scarfing. The welds may be corner, T, or end-to-end. Pieces $\frac{1}{8}$ in. thick should be scarfed, but

not upset. The fire must be small and clean; there should be a flux of some kind used, such as borax or some welding compound.

To make the end-to-end or lap weld with a piece of stock $\frac{1}{16}$ in. by $\frac{1}{2}$ in., heat about $\frac{3}{4}$ in. of the ends in a fire that is open, without very much coke over the pieces. There ought to be a clean bed of coke under them. When the ends are a little more than cherry red, the blast is shut off. Some welding compound is then put on the sides that are turned up in the fire. The blast should be turned on slowly. As the temperature of the pieces is rising to the welding heat, they are turned over in the fire with the fluxed side down. Next a little more blast should be turned on. The heat is right when the pieces are at a little lower temperature than the regular white heat for iron. When hot enough, the pieces are brought to the anvil in the same manner as previously described for other welding. They are lapped about $\frac{1}{8}$ or $\frac{3}{16}$ in. and welded by striking with the hammer on two sides—the flat sides. The edges must not be hammered; they should be cut off with a chisel and then ground or filed to size. This kind of stock should always be welded with separate heats. Riveting or splicing together by splitting the laps should not be done.

T Weld with Round Iron.—The scarf depends on the size of stock. Pieces $\frac{3}{4}$ in. and larger

should always be welded with separate heats. Suppose, for instance, two pieces of 1-in. round iron 10 in. long are to be welded. One piece is

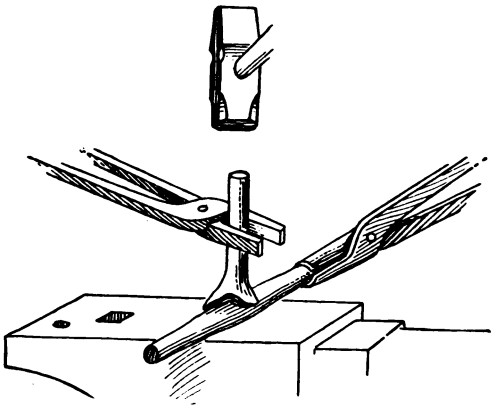


Fig. 28. Welding

heated in the center of the bar and considerably enlarged by upsetting. The other piece is heated on the end and upset, and then caught in a vise and the end split about ¾ in. deep with a thin hot chisel. (See Fig. 26.) Each of the split parts is now scarfed on the inside directly on the end with the hammer. At the same time the scarfs are formed to fit the round part of the other bar. (See Fig. 27.) The bars are now placed in the fire and raised to the welding heat. To do this the fire must be clean. The piece that is split on

the end is placed in the fire so it may be handled with the right hand. The blast is then turned on slowly, having plenty of coke on top of the fire, covering the iron. The fire should also be open in the front and back, with a good bank of coal on the sides. As the pieces begin to heat, a little more blast is turned on, watching them closely so as to get them to a uniform heat and also getting the heat in the right place. When the heat is right, the smith takes both pieces to the anvil, holding the split bar perpendicular and standing

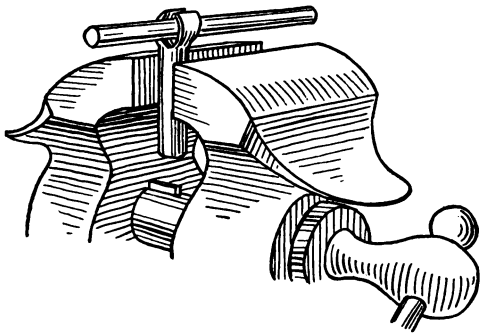


Fig. 29. Scarfs around Small Bars

it on top of the other bar, as shown at Fig. 28. The helper strikes it a few quick blows with a sledge hammer, driving the split end into the other bar and welding it fast. This will force the end of the scarf to spread out a little, letting out

the dirt that may have formed. The smith now turns the piece quickly on its side and welds down the laps with a hand hammer. The work is now swaged to its original size. Small bars are not

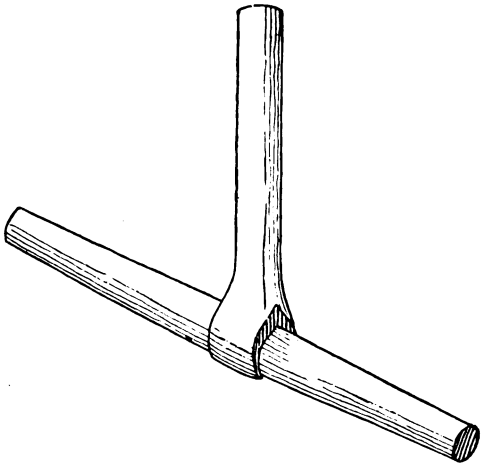


Fig. 30. The Welded Joint

welded with separate heats; therefore the scarfs are left a little longer. When both pieces are prepared, the split lap is hammered around the other bar so it will be tight enough to hold while getting the heat. In doing this the split bar should be held in a vise in order to hammer the laps tight. (See Figs. 29 and 30.) The laps when hammered around this bar should not be so long that the ends touch. If that should be the case, they must be cut off with a sharp chisel while they are still

in the vise. They are then placed in the fire and brought to a red heat. A little flux is now put on and the piece is raised to a welding heat. It is welded by the smith with a hand hammer. The work while hot is fastened in a vise and the end of the lap roughed off with a large coarse file. It may then be reheated and swaged to size.

T, Corner and Cross Welding with Flat or Square Stock.—Suppose two pieces of 1½x⅜-in. stock 6 in. and 10 in. long are to be welded. The long piece is heated in the center and upset. It is then scarfed with the ball of the hammer, or a fuller may be used, working a series of little

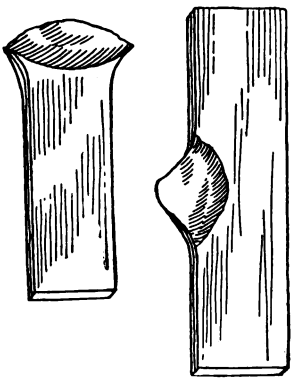


Fig. 31. Scarfing

Fig. 32. Lapped

steps on the lap. The short piece is then upset on one end and scarfed with the hammer as shown in Fig. 31. They are now placed in a clean fire, one that is open in the front and back, with a

bank of coal on each side. The laps are turned down in the fire and the welding heat is raised. The long bar is to be handled in the left hand and the short bar in the right hand. They are taken

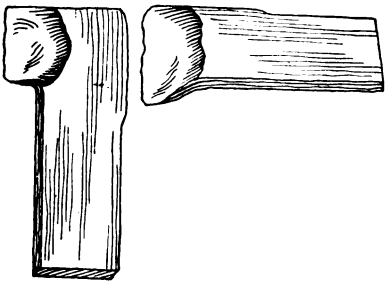


Fig. 33. Scarfs on Corners

to the anvil and lapped as shown in Fig. 32, welding them with the hand hammer and working the corners square with a set hammer.

Corner welds are prepared in the same manner, as shown in Fig. 33, and when the heat is taken they are lapped as shown in Fig. 34. Square bars are also welded in the same way, both T and corner.

Cross welding is a weld in which, when finished, the stock takes the form of a cross. In other words, one bar is crossed at right angles to another. Rectangular stock is generally used in this kind of welding. The pieces are prepared by first upsetting them in the center or at the intersecting points. The scarfs are made with the

ball of the hammer, or a fuller may be used. They are drawn out in the same manner as described for T welding, excepting that each piece has two scarfs opposite to one another, instead of

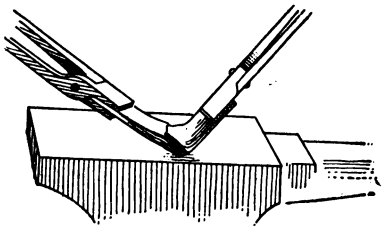


Fig. 34. Lapping Corner Scarfs

one as shown in the cross bar for T welding. The heat is taken and the pieces are lapped with one scarf under the other. When hammered, these thin scarfs lap onto the thick part of the bar and make a smooth weld.

CHAPTER V

WELDING—CONCLUDED.

IN making a jump weld with stock as shown in Fig. 35, a short piece of 1¼-in. square iron is jumped onto a flat piece 3x⅝ in. The square piece is prepared by upsetting the end with a

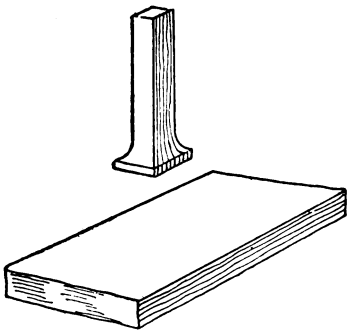


Fig. 35. Stock for a Jump Weld

short heat and fullering a lip on it, as shown in the drawing, or the piece may be upset and then driven into a square heading tool, afterward fullering it so as not to have any sharp corners, for the reason that it is liable to crack while working it. The bottom part of this bar should be hammered slightly convex in order to let the slag work

out when welding it. The bottom piece, 3x5/8 in., if intended to be 5/8 in. thick when finished, should be heated in the center and upset; but if it is intended for a short forging, it is better to

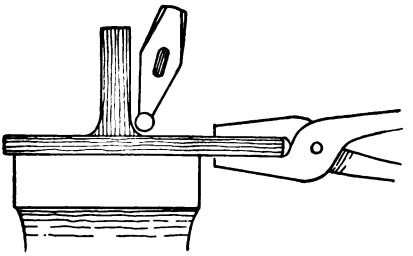


Fig. 36. Making a Jump Weld

use a thicker piece, drawing it to size after the weld is made.

After the pieces are prepared, the fire should be thoroughly cleaned and built up with a good bed of loose, well coked coal. The square piece is placed into the fire so that it may be handled with the right hand. It may be caught in the tongs at right angles to them. The flat piece is caught at one end with the tongs in the left hand. The pieces are heated slowly at first, in order to heat them throughout. Heating iron of this kind too quickly gets the outer parts hot and not the inside. The pieces, while heating, should be turned over once in a while, helping to promote an even heat. As the welding heat begins to rise, a little more blast should be turned on, gradually

giving all the blast the fire will stand. The pieces are then taken to the anvil, at the same time giving them a knock to dislodge the dirt. The flat piece is turned over with the side up that was down in the fire; the square piece is set onto it, and the helper gives a few quick, sharp blows with the sledge hammer. The smith now lets go of the tongs in the right hand and with a set hammer or fuller follows around the lap while the helper strikes the tool quick blows. (See Fig. 36.) The piece may now be reheated and finished to size.

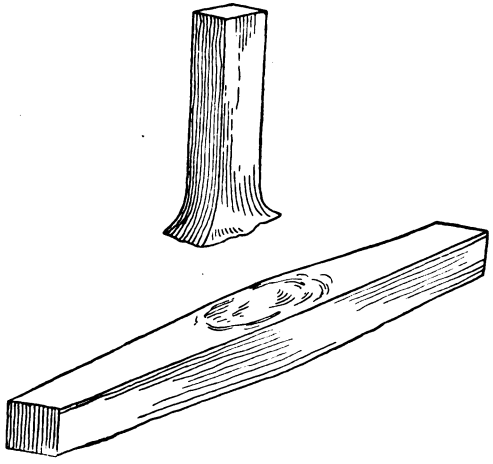


Fig. 37. Stock Prepared for a T Jump Weld

Fig. 37 shows how rectangular stock of the same size is prepared for a T when making a jump weld. Note that the lap is worked out

from two sides only. This kind of weld is hammered in the same manner as previously described for jump welding. Square stock of the same size may be welded by scarfing instead of with a jump

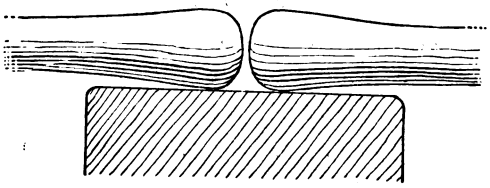


Fig. 38. Butt Welding

weld, if desired, but if the lower piece, Fig. 37, were a flat one it would be welded with a jump weld for the reason that, being thin, it could not be scarfed readily.

Butt Welding.—Sometimes heavy bars are welded by butting the ends together as shown in Fig. 38. In making the butt weld the heat is taken on the ends of the bars. One piece is taken to the anvil by the helper; the other is handled by the smith. Butting the two hot ends together, a second helper strikes on the end of one bar with a sledge hammer while the smith holds them firm. As the hot ends begin to unite, the smith and the other helper strike on the part uniting, welding them together. In preparing the ends of the bars to be butted, they are heated

on the end and hammered slightly convex so as to allow the dirt to drop out while welding. When the weld is made they are swaged to their original size.

Welding Flat Rings.—In making flat rings the stock is heated and bent on its edge. Care must be taken while working it to keep it from buckling, also to keep its edges the same thickness, as in bending the iron must upset on the inner edge and stretch on the outer edge. To avoid this, it should be flattened on its sides while bending. This is done with the flatter and sledge hammer. When it is bent into shape it will look like A, Fig. 39. It should be cut off on the dotted lines and then scarfed. It is now heated

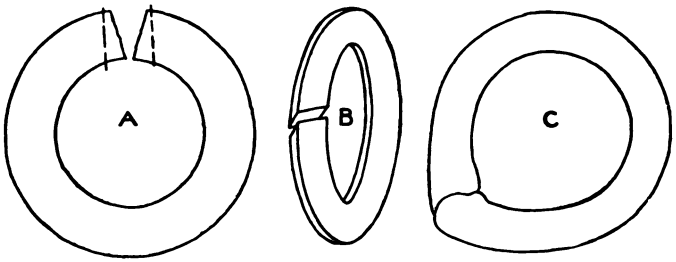


Fig. 39. Welding Flat Rings

and again bent so that the scarfs will lap each other the proper distance. They should not be driven down too tight. It is better to have them a little open in order to knock the dirt out, as

shown at B. When the heat is raised, the piece is welded by hammering on the flat sides first, then slipped over the horn of the anvil, in order to work down the edge. It is afterward rounded into shape.

In welding rings of square or rounded stock the length is first determined. The piece may be heated and bent into shape (or some rings may be formed cold); the ends are then heated and scarfed on the side, leaving the ring somewhat egg-shaped, as shown at C. The reason for this is that the heat can be taken directly on the laps. The ring is welded by first hammering it on the sides, then on the horn of the anvil.

Sometimes the stock for rings is upset and scarfed on each end and afterward bent in shape, but this is rarely necessary.

Bands and hoops are welded in the same manner as described above.

To find the amount of stock necessary to make a ring, hoop or band add together the thickness of the stock and the diameter of the inside of the ring, and multiply this by $3\frac{1}{7}$.

Example: Suppose a ring is required of 1-in. stock, with the inside diameter 10 in.

Solution: $(10+1) \times 3\frac{1}{7}=11 \times 3\frac{1}{7}=34\frac{4}{7}$ in. To this should be added the amount required for waste in making the weld, in this case about $\frac{3}{8}$ in.

Rings made from flat stock are hammered over the horn of the anvil to shape them. The ends are scarfed on the horn and lapped the proper distance; then a heat is taken, and the ring welded

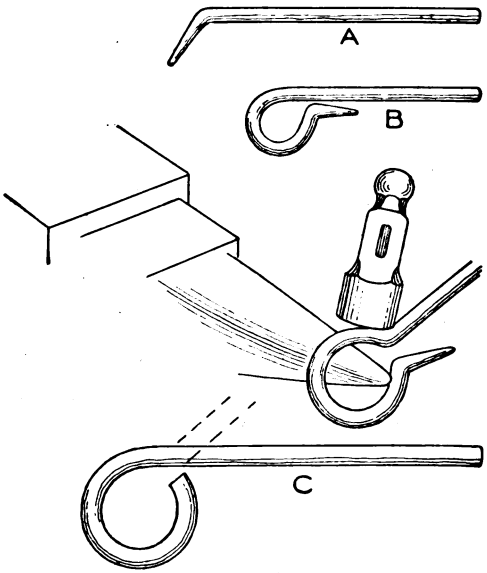


Fig. 40. Ordinary Ring Welding

and rounded into shape. A ring may be made by scarfing the ends of the bar before it is turned in ring form, but this is seldom necessary.

Another kind of ring welding is to turn an eye or ring on the end of a bar. To do this the bar is heated at the end, drawn square to a point,

and then bent at an angle over the edge of anvil. (See Fig. 40 at A.) The bar is again heated and the ring formed to the desired size. (See B.) It is then bent by striking it with the

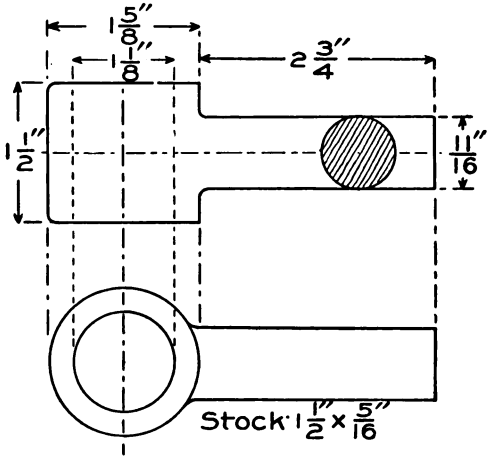


Fig. 41. Welded Eye from Flat Stock

edge of the face of hammer as shown in drawing. A heat is now taken and it is welded by striking first the part near the ring, in order to weld that part first. After all is welded it may be smoothed in the swages. In turning a loose ring, the method of forming is the same. The amount of stock is first found and the rod is cut off. The end is heated and a ring turned just the size needed. The piece is again heated and bent on

the horn by striking it with the hammer, as explained in ring welding and shown by the arrow at C.

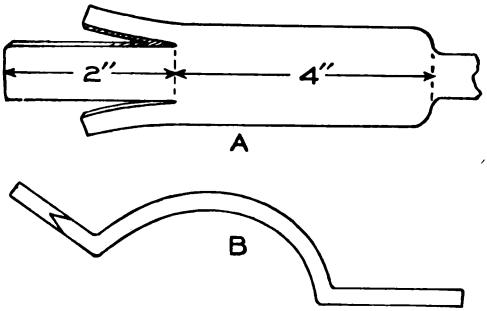


Fig. 42. First Steps in Making an Eye Weld

Fig. 41 shows a welded eye made from flat stock. The method here is to heat the bar and split the end for 2 in. (See Fig. 42 at A.) The outside prongs are cut shorter and drawn chisel-shape. A shoulder is hammered 4 in. from the end of splits, as shown on drawing. The entire piece is now heated and formed as at B. It is then hammered around the horn of the anvil and the prongs or laps fitted as shown in Fig. 43. A heat is raised and the heavy prong welded first; at the same time the outside ones are hammered, welding them around the eye; the shank is swaged to size, and when the forging is finished it will appear solid.

Chains.—Ornamental and plain chains are much used to hang lanterns and electroliers. The links may be welded, brazed, and oftentimes with their ends butted together. The stock may be round or rectangular.

Square stock may be twisted. In that case the length of link is first found and cut off, and then heated and formed by hammering over a piece of hardwood which is fastened in a vise. Twisted links should be made quite long and not welded, the ends being butted together and brazed.

Links from round stock may be made by first finding the center of the bar that is to be the link and marking it with a center punch. One-half

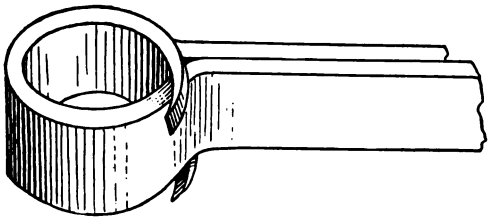


Fig. 43. Fitting the Prongs in an Eye Weld

of the bar is heated and a round eye turned by hammering it over the horn of the anvil. The other half of the bar is heated and an eye turned so that when finished it will be at right angles

to the first one turned. This is what is termed a double link. Round stock may also be turned in a U-shape having the ends even. The U is then welded. In doing this the ends of the U may be scarfed on the side of bar, then hammered over the horn so that one lap passes the other. A heat is taken and the link welded by hammering it on the sides and then on the horn of the anvil.

Links from light stock should not be scarfed, but hammered while cold over the horn until the ends of the U are lapped the proper distance, a heat being then taken and the link welded.

A small fire should be used for welding light links such as $\frac{7}{16}$ in. and smaller. The fire should be well banked on the sides and back with wet coal, leaving a small opening at the front and top to take in the heat. Links and rings from round stock, when lapped either with or without scarfing, should be very pointed and not formed round. The reason for this is that, in taking a welding heat on any kind of stock that has been lapped together in the manner described above, there is more or less waste each side of the laps, and always danger of burning the stock before the laps are raised to the welding heat. After a link is welded it may be heated and given a quarter turn to the right by catching each end with a pair of tongs and twisting.

Brazing.—Two or more pieces of iron or steel may be fastened together by brazing them with spelter. Spelter is a mixture of about one part of copper and two parts of zinc. The more copper is added and the less zinc, the more heat is required to melt it, and the stronger the spelter will be.

Brass may be brazed by using spelter, but requires more care in heating. In this case the spelter should contain more zinc than is in the mixture of brass, so that when heated the spelter will flow before the brass is melted.

Copper may also be brazed with spelter. This metal is much easier to braze than brass, as it will stand a much higher heat before melting.

In brazing iron or steel, brass wire or sheet brass may be used if desired. The pieces to be brazed should be fitted to a reasonably close joint, and the joints or laps should be dressed with a file in order to have them clean and free from any foreign matter. The pieces must be fastened together so that they are firm while brazing. This may be done by riveting, or binding them with wire. When fastened they are placed in a clean fire—one with a well burned bed of coke. Fresh coal must not be placed on the fire while brazing. The pieces may be heated with a very little blast until a red heat is reached; then it is shut off. A flux, such as borax, is now placed on the joint,

and when it is well burned the spelter is put on. The blast is then turned on, and when the pieces have reached the right heat the spelter will melt and flow through the joint. The pieces are now taken out of the fire, and at the same time they are turned over a few times so that the spelter will not run to the under side and settle in a lump. The joint when brazed, and while it is still hot, is scraped with a file in order to remove the surplus borax and scale that always remains. In doing this care must be taken, as brass is very brittle when hot, and any rough treatment is liable to fracture the joint. If the pieces be allowed to cool without being cleaned, the borax will be very hard to remove, as it becomes glazed, due to the heat of the fire.

Brazing is a simple process, and after a little practice one will have no trouble.

CHAPTER VI

TWISTS, SPIRALS, ETC.

TO relieve the monotony of plain surfaces square and flat bars of iron are sometimes twisted, and many pleasing effects are thus obtained. It requires a trained eye to determine the

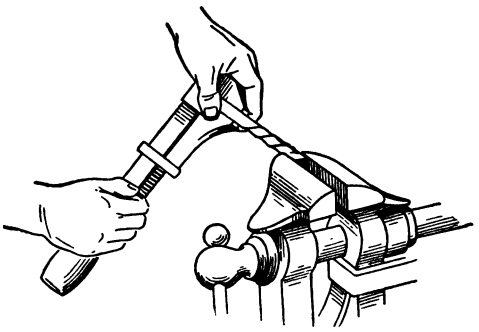
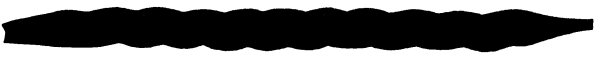


Fig. 44. Twisting a Bar

proper spacing of the twists. They should be of uniform distances apart in order to appear the best. There are many shapes that may be twisted to advantage, such as square, flat and hexagon, and round bars with two or more twisted together; also bars that are tapered and swelled. All of these are very pleasing.

In twisting there are two methods. Flat bars that are not too heavy may be twisted *while cold,* providing the stock is of the same thickness throughout its length. If it be swelled or tapered it must be twisted while hot. The operation of twisting *while the iron is hot* is very simple. Say, for example, a bar 10 in. long and ½ in. square is to be twisted its entire length. The piece should be cut about 11 in. long. The extra inch is left on until the piece is twisted in order that there may be extra stock to catch in the vise, and when twisted it is cut off. The piece is heated as much at one time as possible in a forge. The heat must be uniform and about yellow; it must not be a welding heat, as this destroys the texture of the iron. When the bar is heated it is caught by one end in a vise, and with a monkey wrench on the other end it is twisted to the right. (See Fig. 44.) If any part of the bar is twisting faster than another, or too much, a little stream of water is poured on the part twisting too fast. In case one part is twisted more than is desired it may be remedied by reheating it and cooling each side with water, then twisting back as desired. A little practice will enable one to get them uniform.

In Fig. 45 may be seen some illustrations of twisted bars. At A three bars of ¼-in. round iron are welded at the ends, and are then heated



A

B

C

D

E

Fig. 45. Various Forms of Twisted Bars

to a uniform heat and twisted. Twists of this kind, with possibly more bars, make very nice handles for pokers and shovels. At B a piece of ½-in. square iron is twisted. At C a piece of

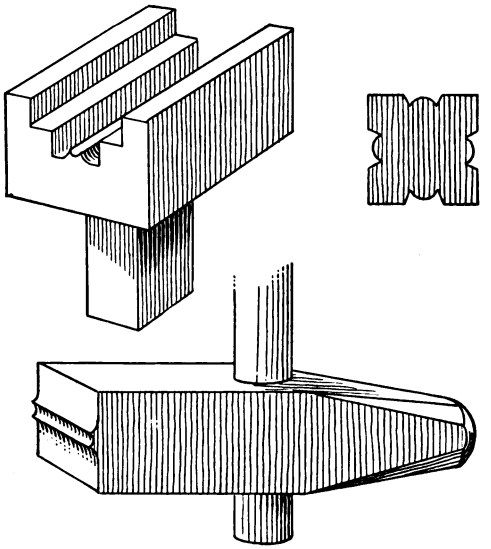


Fig. 46. Section of a Twisted Bar and Tools Used in Swaging

flat stock has been used. This kind of stock twisted is better for gates and grilles. At D a piece of ⅝-in. oval has been used. This form is very good for handles of shovels, especially if it be swelled or tapered. At E is a very pleasing twist. It is a piece of ½-in. square with a bead swaged lengthwise on its four sides. A section of this is shown in Fig. 46, also the tools used to

swage it, which consist of a bottom swage to fit the square hole in anvil, and a top swage with a wooden handle. To swage the bead the piece is heated and set into the bottom swage; the top swage is set onto it, and the helper strikes it with the sledge hammer; at the same time the piece is moved along the swage, turning it over occasionally. After the bead is swaged it is heated uniformly and twisted in the same manner as previously explained in twisting square stock. In Fig. 47 are shown a poker, tongs and shovel, with a rack, made of square stock twisted.

Another form of twisting is to give a flat bar a series of half-turns at equal distances apart. This may be used to advantage in the making of light grille work. The bars should be very light, say $\frac{1}{16}$ in. thick. When twisted they are interlaced and riveted, forming meshwork. The mesh is produced with the edges toward the eye, and the flat part of the bar is crossed and riveted at the intersections. The tool used for twisting flat bars is shown in Fig. 48. It may be made by simply riveting four pieces of $\frac{1}{4}$x$\frac{3}{4}$-in. soft steel at right angles to a bar $2\frac{1}{2}$x$\frac{1}{4}$ in. The pieces should be riveted in pairs, and in such a way as to leave a slot at the top. This slot is to receive the bar that is to be twisted. After the flat bar is placed in the slot it is given a quarter turn with the tool, which also has a slot in its end

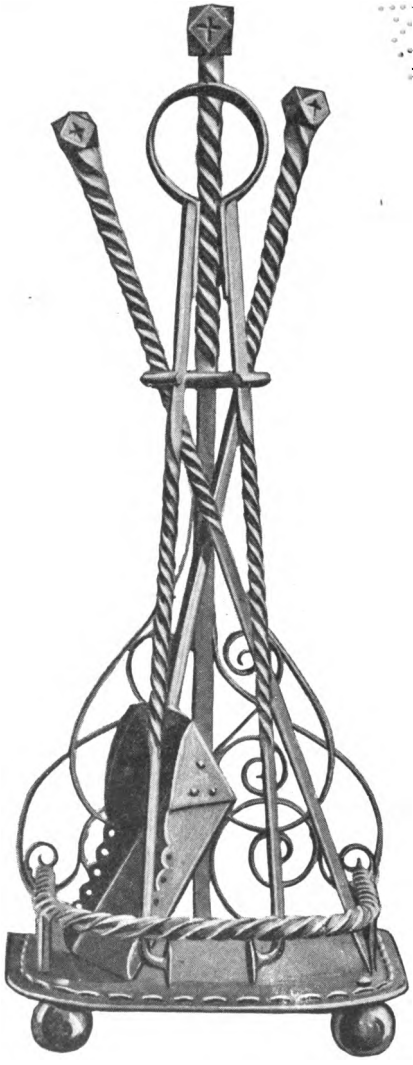


Fig. 47. Fire Set Made of Square Stock

to fit the bar being twisted, the result being that the edge of the twisted part is now at right angles to the flat part of the bar. The twisting is done while the stock is cold, and soft steel should be

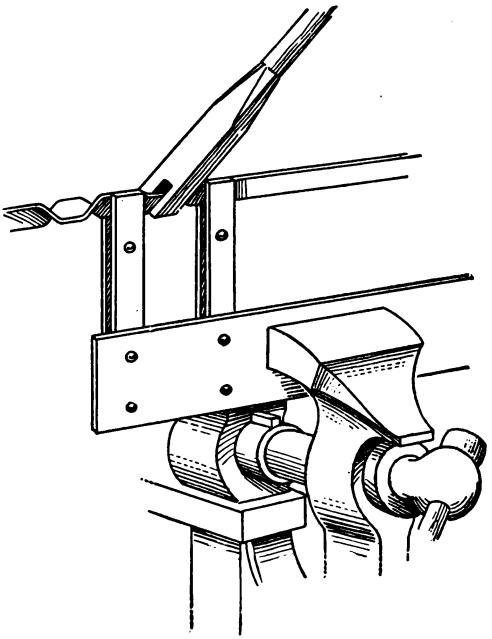


Fig. 48. Twisting Flat Bars

used, as iron will not stand the strain of the twisting. The main thing to look out for in twisting the bars is to have the turns at equal distances apart in order to have the mesh work equal. (See Fig. 49.) The size of mesh should be determined

and then the tool made to suit it, or the bars may be marked at the proper distances and then twisted. This kind of grille work may be greatly enhanced by introducing scrollwork in connection with the twists.

Fig. 50 shows a grille consisting of scroll and twist. The bars are turned into a scroll at the ends, forming a border. The frame is made

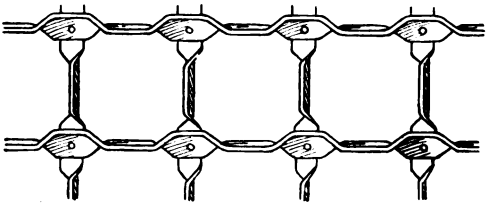


Fig. 49. Mesh of Twisted Flat Bars

from a small channel, and the scroll ends of twisted bars fit into the channel. At the top of the grille the scroll alternates with a bar which is formed into a ribbon. A great variety of this kind of grille work may be made with the twist and scroll and with the addition of other details.

Four pieces of round soft steel twisted together may be used as a handle for a poker or shovel. To do this a piece of $\frac{3}{16}$-in. round is cut 12 in. long, heated in the center and bent so that the ends meet. After hammering the two rods together, the piece is again heated, catching one

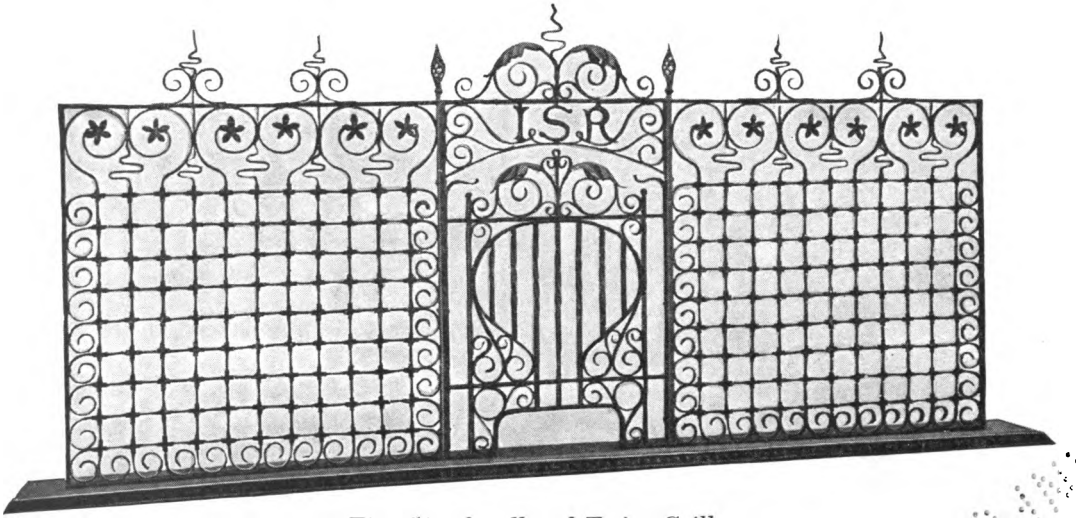


Fig. 50. Scroll-and-Twist Grille

Visual Contact

end in a vise and twisting to the right with a pair of tongs. The piece is shown in Fig. 51, at A. Another is made in the same manner, and the two are welded together at one end, as shown at B. If the handle is intended for a poker a

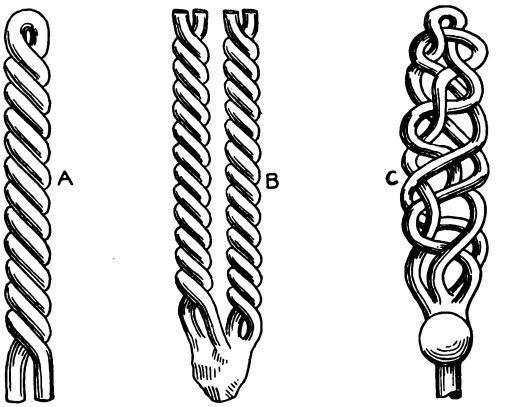


Fig. 51. A Braided Handle

piece of 3/8-in. round may be welded to it, and a small collar is welded at the base of the twists to give it a finish. The top part may also be welded and an eye turned at the end. The entire handle is now heated and twisted to the right. It should be twisted considerably, and it must be kept straight and not allowed to get out of shape. Then the handle is heated again, and it is twisted to the left until it appears as shown at C, forming a braided effect.

Spirals.—In Fig. 52 are shown a number of spindle-shaped spiral twists made from round stock and formed by hand with the aid of the hammer and anvil. Spirals of this kind may be used as embellishments in grille work, as finials, or as the tendrils required in some foliated designs.

The method of forming these spirals is very simple. The main thing in working them up is to have the twists true and uniform in spacing. In forming a spiral a piece of ¼-in. round soft steel is first heated on one end, and a considerable part of its length is drawn out with the hand hammer, giving it a long taper to a point at the end. The amount of stock required for the spiral is found, then measured from the point along the bar, bending it at right angles. About an inch of the point is also bent at right angles. The part of the bar that is to be formed into spiral shape is now heated. Starting at the point, it is rolled up by striking it with the hand hammer until one-half of the bar is coiled. The other half of the bar is now heated, and, starting at the corner of the bend, the rest of the bar is rolled into a coil until it overlaps the first coil.

The illustration in Fig. 53 fully shows at A the method employed in this operation. The entire piece is now heated, and, catching the point and the stem with a pair of tongs, the coils are

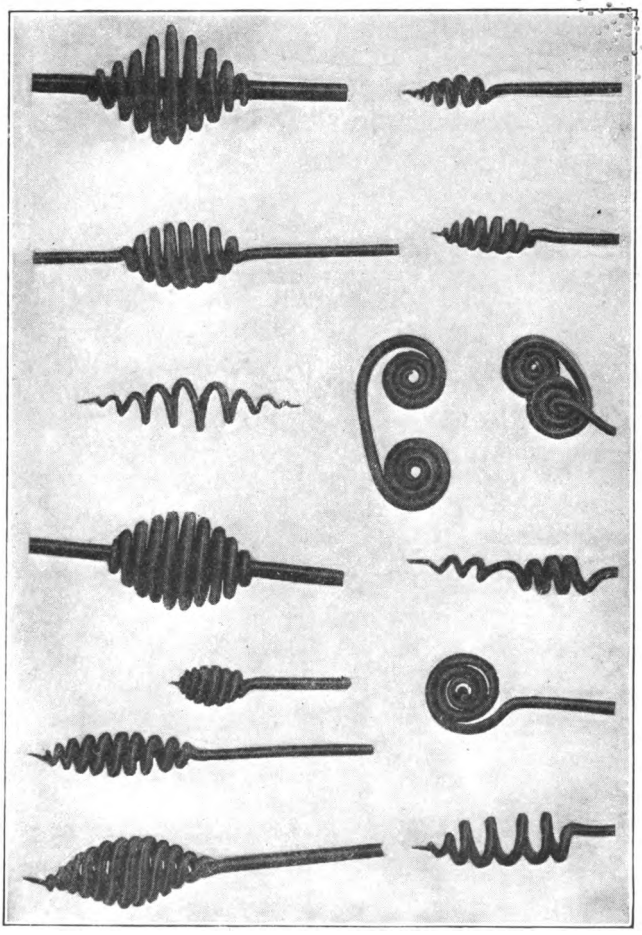


Fig. 52. Spindle-Shaped Spirals

CAPITAL CONTROLS

pulled apart as shown at B. The spiral is again heated, and, setting it in a bottom swage, it is hammered with a light hammer to round it. If any of the coils are too close or too far apart they may be trued with a tool like a screwdriver and

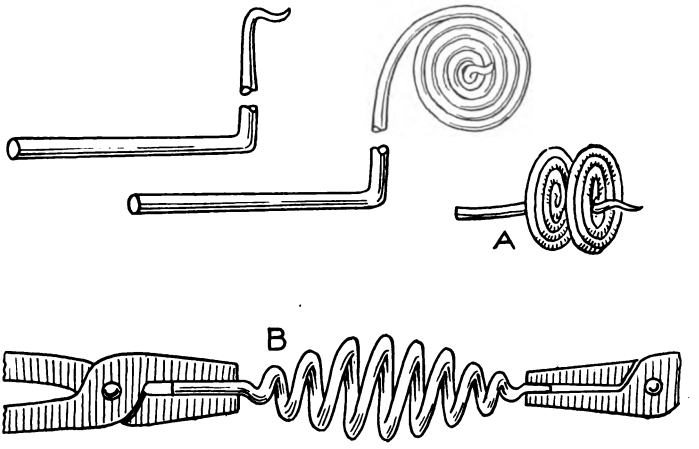


Fig. 53. Method of Forming Spirals

which has a wide blade. This is done by heating the spiral and pressing the coils together, then pressing the blade of the tool between the coils, giving it a twist, and thus forcing the coils apart. It is best to start at one end of the spiral and continue to the other end, moving each coil that needs it with the tool.

Two spirals of this kind may be twisted into one another, afterward welding the stem to-

gether. The points may be twisted together also. A spiral of this kind is shown at A in Fig. 53.

The Bulb.—Another form in twisting is to weld together a number of round or square rods

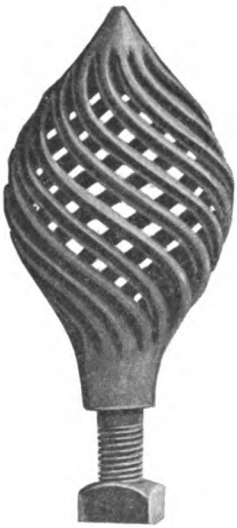


Fig. 54. A Twisted Bulb

at their ends, and then twist and swell them in the center in bulb form, as shown in Fig. 54. There are thirteen soft steel rods $\frac{1}{4}$ in. round in the bulb. The length of the rods before welding is $7\frac{1}{2}$ in. Soft steel is used because iron will not stand the strain of twisting without danger of breaking.

The method of forging the bulb is first to get out two pieces of iron to be welded in the top and bottom, also three short pieces of round to be placed in the center of the rods while welding the ends. These pieces are shown at A in Fig. 55; also the dimensions. At B are shown the

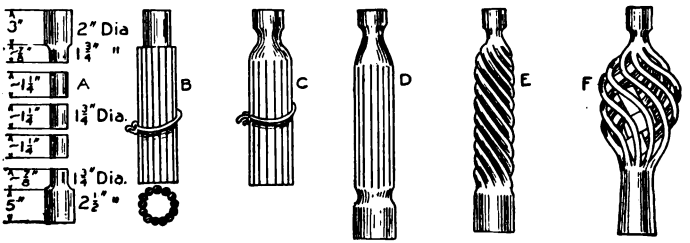


Fig. 55. Method of Forging the Bulb

top four pieces placed on the inside of the rods. A strong wire is twisted around them, binding the whole firmly. The weld is now made at the top, welding the small rods to the heavy piece of iron on the end. In making this weld some welding-flux must be used. The rods are welded directly on their ends. So the heat must be taken on the heavy piece first, gradually pushing the pieces a little farther into the fire until the heat reaches the end of the small rods. The work, while raising the heat, is held with a pair of round-nose tongs with a ring on the end of handles. The tongs should fit and hold the pieces

firmly. In case the piece being heated at the end of the rods should want to drop out, it may be held in place by using a poker that has a short right angle bent at its end, and the rods may be tapped with the poker to stick them enough to hold fast before taking the piece to the anvil. After the end is welded it is drawn out as shown at C. The bottom piece is now inserted and welded as at D. The entire piece is now heated uniformly to a yellow heat, one end is caught in a vise, and with a monkey wrench on the other end the rods are twisted to the right as much as they will stand without danger of breaking. At the same time they are tapped on the end in order to help the rods twist. The piece will now appear as at E. It will be necessary to take more than one heat to twist the rods as much as they will stand. When this is done the entire piece is heated again and twisted to the left. At the same time it is tapped on the end with a hammer to help open the bulb as shown at F. Two of the rods are now spread a little to let the three pieces of round iron drop out. These were kept on the inside to keep the small rods in shape while welding and twisting them into shape. The lug at the top is now drawn a little more pointed and the bottom end swaged $\frac{5}{8}$ in. round. A thread is to be cut on this end. The rods in the bulb are trued by heating and catching them in a vise in

a vertical position. A long, slim punch is used to force any rod into its proper position. If a rod needs moving a little to correct its shape, it is done by setting the punch

Fig. 56. Bulb Made of Square Rods

against it and striking it with a hammer. After the bottom part of the bulb is trued it is turned over in the vise and the top part trued. When this is done the knob at the top is cut off. The bulb is now annealed by heating and letting it cool, when it is again trued. If any part of the

rods needs a little rectifying, it is done with the punch and hammer by setting the bulb over the hole in the anvil or catching it in a vise. The bottom end is threaded so the bulb can be screwed into the top of an andiron or wherever it is to be used.

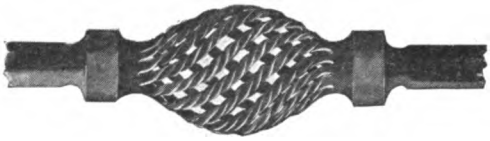


Fig. 57. Bulb in Center of Bar

Bulbs of this kind may be made on the end of a bar if desired, making the whole one piece. The bulb may also be made of square rods twisted and then worked in bulb form as shown in Fig. 56, or they may be made in the center of a bar, as in Fig. 57.

Balls and Cubes.—In working up a solid ball or cube several methods may be employed. The stock used in forging balls should be round. For forming cubes or octagonals square stock is best. One method of forging them is to use a heavy piece of stock, drawing the metal away from the part that is to be the ball or cube. Or a collar may be welded at the end of a light bar, then working the collar in the form desired. Another method is to upset the end of a light bar and work the form into shape.

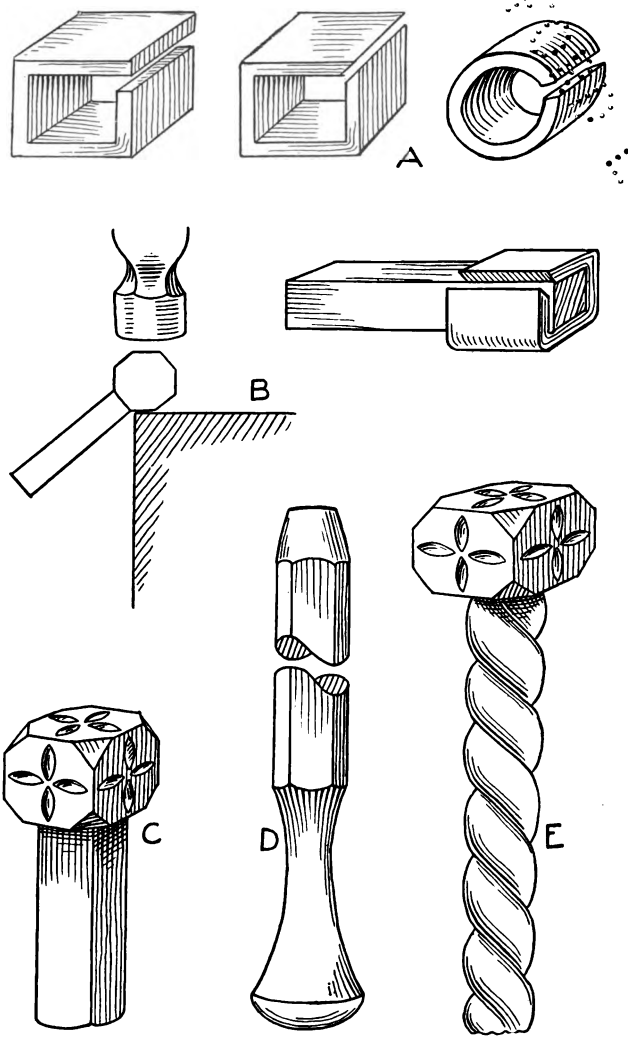


Fig. 58. Square and Round Collars

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The best method to use depends on the size of ball wanted. If it is to be a small one, upsetting is a good method, but, if the ball is to be large, welding a collar or forging from the solid is preferable. If a ball alone is desired it is worked at the end of a bar, and when finished it is cut off. If a ball or cube is to be used as a finish at the end of a shovel or poker handle, it is generally forged on the end of a bar that is to be used for the handle, or it may be forged with a short tang and then welded to the handle. In working up a round or octagonal head that may be used at the end of a poker or at the top of an andiron the methods are the same, varying only in size.

In welding a round collar of any kind onto another bar, the collar is formed and cut so that when driven on there will be an opening between the two ends of the collar. The reason for this is that in the operation of welding the collar will be stretched by the blows of the hammer and there must be room for the ends to lengthen. In the case of a square collar there is not so much danger, as it is hammered on four sides, giving the sides a chance to upset.

In Fig. 58, at A, are shown square and round collars as they would appear when ready to be welded on a bar, either at the end or other part of the bar. After a square collar is welded it

may be formed into an octagonal shape by hammering on the corners, as shown at B, working the cube into a number of flat parts that give it interest. It may be further enriched by sinking depressions in the sides as shown at C. This is done while the metal is hot, with a chisel ground with a short bevel and rounded across the face, as shown at D. The head, if large, will make an ap-

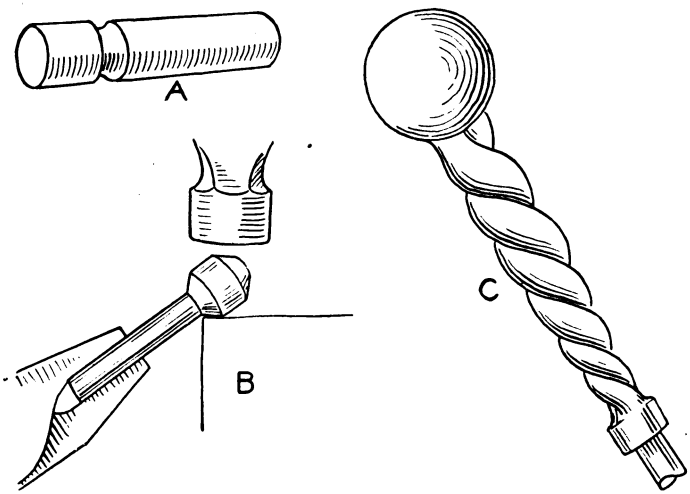

Fig. 59. Working Up a Ball

propriate top for andirons, and if small may be used at the end of a shovel or poker. It may be further enriched by introducing the twist in connection with it, as shown at E.

In working out the ball a collar may be welded at the end, or the stock may be fullered as shown in Fig. 59, at A. If a ball only is wanted the end is hammered round and finished, then cut off. However, if it is to be the end for a handle or

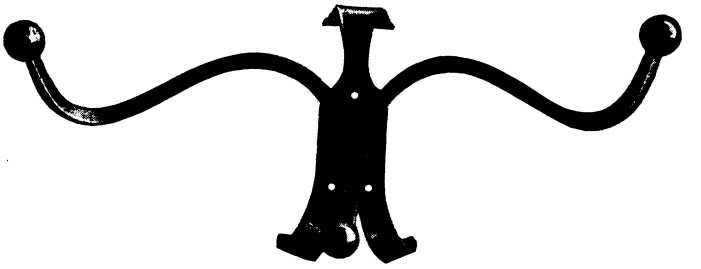

Fig. 60. Hat and Coat Rack

some other useful part in ironwork, the shank is drawn out, and the ball is worked up by hammering it on the anvil, first by hammering the edge, as shown at B, then rounding into shape. If the ball is to be used for the end of a poker, the handle may be squared and enriched by twisting as shown at C.

Fig. 60 shows a simple hat and coat rack consisting of two pieces of ½-in. square iron welded together, with a ball worked at each end as shown in cut, and riveted to a plate ⅛ in. thick. Screw-holes are drilled so that it may be fastened in place.

Banding.—Two or more pieces of stock may be fastened together with a band or collar. The stock may be of any size or shape, but bands are generally made from rectangular or half-round, and often swaged in ornamental shapes. The stock is first bent in a U shape and then ham-

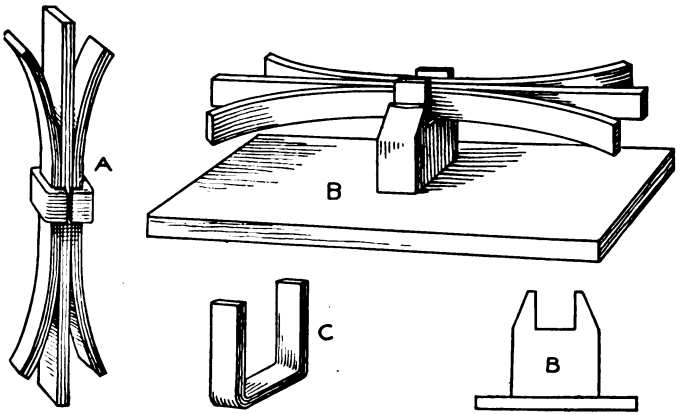

Fig. 61. Banding Flat Bars

mered around the bars to be fastened together. In doing this the band may be heated, or, if it is of light stock, it may be hammered cold. Bands are mostly used in grille and scrollwork, and they become one of the ornamental parts, as well as serving to make the part immovable.

In Fig. 61, at A, three flat bars are shown fastened together with a band. In banding stock of

this kind a simple tool is used to keep the bands from spreading while hammering around the bars. The tool consists of a plate ½ in. thick and 5 in. square with an upright piece riveted into the plate. (See drawing of tool at B.) The tool is made to be set on a bench or platform. One

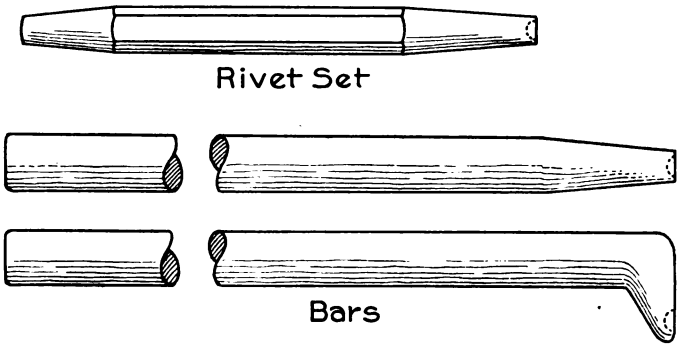

Fig. 62. Tools Used in Riveting

may also be made to fit the square hole in the anvil, or it may be used in a vise. To fasten a band as shown at A, the U shape C is first set into the slot in the tool, the three bars are laid on the inside with their edges up, and the ends of the band are then hammered tightly.

Riveting.—A rivet will render parts immovable if it is headed on each side and drawn tight with a hammer. If a hole is drilled through two pieces of iron and countersunk or enlarged at each end, and a rivet inserted, hammering it tight,

the head may be dressed smooth with the surface of iron and the pieces will be immovable. This kind of riveting is called countersunk-head riveting. A rivet may also be headed on each side with

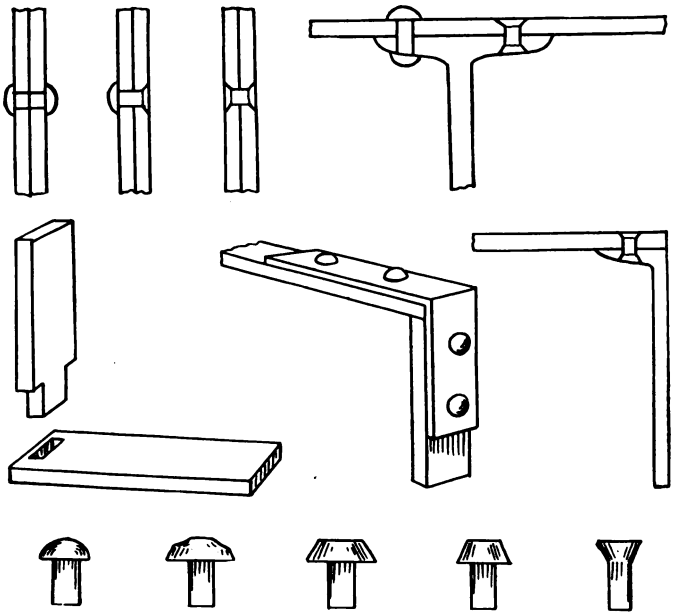

Fig. 63. Methods of Riveting

a round head, or smooth on one side. In riveting with a head on both sides, the head of the rivet is held with a bar. This bar should have a sink in its end to fit the head of the rivet. The other end of the rivet is then hammered, and a rivet

set is used to finish it. See Fig. 62 for these tools. Corners of frames are also riveted instead of welded. They may also be made with a tenon and then riveted, or an angle plate may be riveted on a corner. Rivet heads may be made in any shape in order to get a pleasing effect. In Fig. 63 various methods of riveting are illustrated.

CHAPTER VII

SCROLLWORK

THE scroll form is used extensively in decorative ironwork, and there are many methods of shaping and working it. The one explained here is by hand with the use of simple tools. The

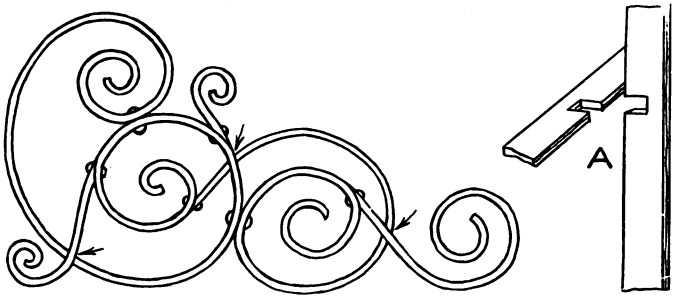

Fig. 64. Riveted Scrollwork

scroll may be formed from any size or kind of stock, the size and shape depending on its use and the position it is to occupy. Scrolls may be turned separately and then fastened in position with rivets, or they may be fastened with bands or collars heated and shrunk onto two or more members, binding them firmly. Another method is to weld and afterward form them into shape.

This requires a little more skill, but makes the best job. Scrollwork is also improved by introducing the leaf form in connection with it. This is mostly used in grille work.

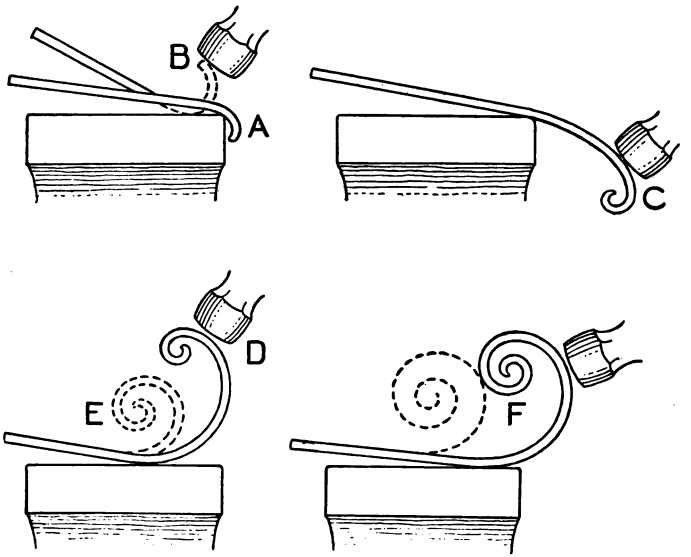

Fig. 65. Forming a Scroll

In combining two or more scrolls the first thing to be done is to make a full-size drawing of the design on a surface plate or drafting-board. A surface plate is a plate of cast iron planed smooth on one side. It may be 3 ft. square or larger. It should have iron or wooden legs about 3 ft. high. A drafting-board is simply a few boards

nailed together with one side smooth and painted black. It may be placed on legs or trestles. Say that a piece of scrollwork as in Fig. 64 is to be made from 1x¼-in. soft steel. The drawing shows each member fastened with a rivet. The design must first be drawn with chalk, full size, on the drafting-board, and each member must be fitted to the drawing. To do this the largest piece in the design is measured to find its length. This is done by using a string. Starting with the end of the string at one end of the scroll, it is laid over the entire outline until it comes to the other end. It is then cut or a knot tied in it. The length of the string as cut, or up to this knot, is the length

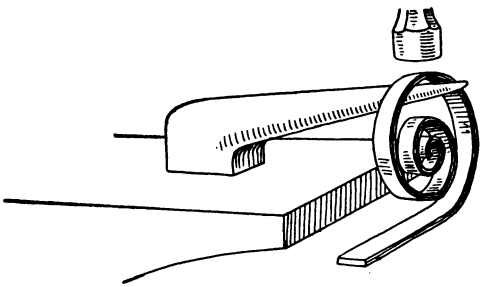

Fig. 66. Perfecting a Scroll

to cut the stock. The next largest scroll is now measured and cut, and then the three small ones.

In forming a scroll, the stock is heated on the end and the eye turned first. In doing this the

piece is hammered over the outer edge of the anvil, bending it as shown in Fig. 65, at A. It is then turned over onto the anvil and tapped down as shown at B, at the same time forming the eye

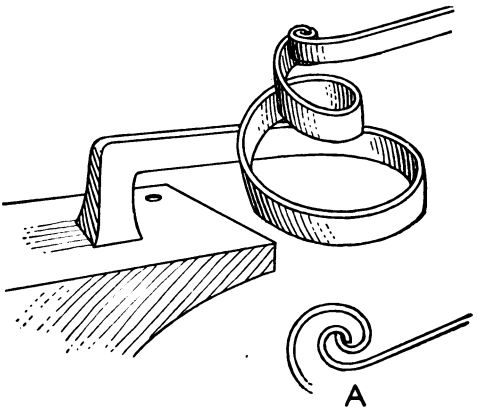

Fig. 67. Former for Scroll-Bending

round without any kinks. The completed eye should be formed with this heat. It is again heated and further formed by hammering it as shown at C. It is then turned over and hammered as at D, rolling it in shape as shown at E. It is now reheated, and the part already formed may be kept cool in order not to bend it out of shape. Next it is hammered as shown at F. The sketches fully show the method of forming, and with a little practice the bending will become easy.

In forming these scrolls the stock should not be heated too hot. A red heat is about right. In hammering, the piece held in the hand should be moved up and down while it is struck with the

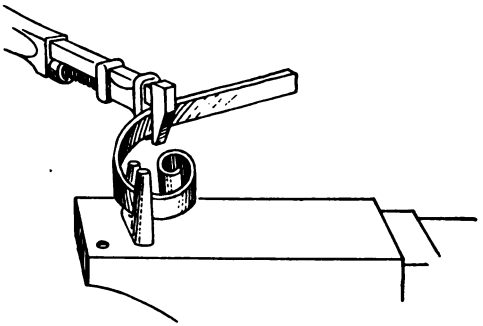

Fig. 68. Forming the Body of a Scroll

hammer, in order to roll it into shape at the proper place. The straighter curves may be formed cold with the monkey wrench and bending-fork. The work should be tried on the drawing as it is being formed.

After the scrolls are formed in the manner described above, if there should be any parts that need a little rectifying, it may be done on the horn of the anvil by striking the piece with the hammer at the proper place, or, if the scroll is a closely coiled one, it may be rectified by hammering it on a small horn that fits the square hole in the anvil, as in Fig. 66.

When the scrolls are all formed and fit the drawing, the ends are drawn on a taper. Where one member crosses another, as shown by the arrows in Fig. 64, they are halved together. This is done by filing half through each bar as shown

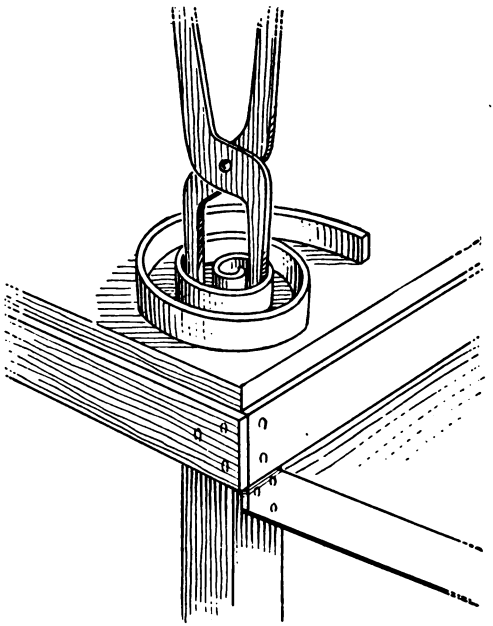

Fig. 69. Rectifying a Scroll

at A in Fig. 64. When all are fitted the holes are drilled and the rivets are put in, using a rivet set to finish the heads.

In some designs there are a number of scrolls

of the same size, and in order to produce these quickly and uniformly they are shaped over a tool called a former. Fig. 67 shows a former for this kind of bending. It is made of flat stock, excepting the part that fits into the square hole of the anvil. To make this former a heavy piece of iron is welded to a flat piece, and the flat part is hammered into scroll shape with the hand hammer as previously explained for scrollwork. The heavy piece is to fit the square hole in the anvil. The former ought to be shaped the same size as the scroll wanted. After it is formed it is heated, and with a pair of tongs the eye is caught and pulled out, giving it the spiral shape shown in the drawing.

The method of forming a scroll with this tool is first to heat the bar and hammer a little hook or eye at the end, or it may be hammered over a form. The bar with the hook at the end is shown at A, Fig. 67. The bar is then heated its entire length, or enough to form the body of the scroll, and the eye at the end of the bar is hooked over the top of the former and is wound around it. If the bar does not hug the former it may be given a blow with the hammer where needed. The scroll is now lifted off the former, and as it will be spiral shape it must be pressed flat. This is done by setting it onto the surface plate while still hot, and then pressing it flat with the hammer.

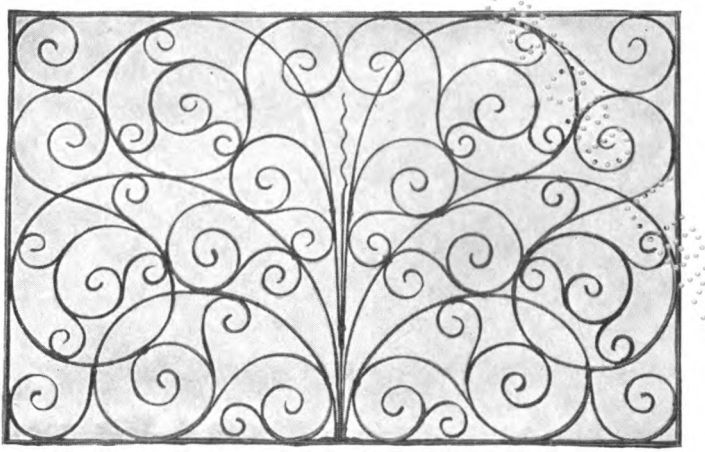

Fig. 70. Grille of Flat Scrollwork

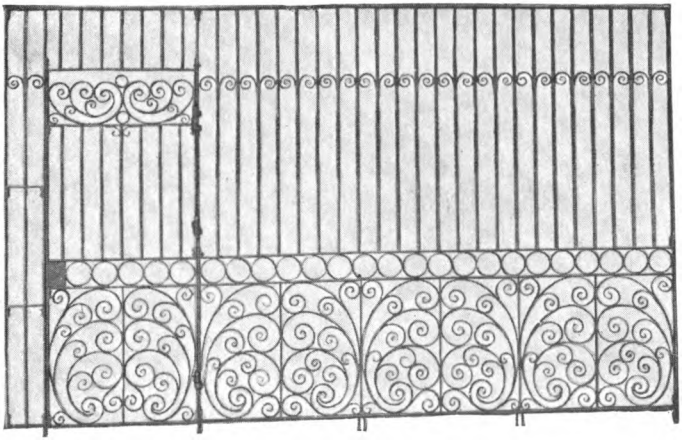

Fig. 71. Another Grille of Flat Scrollwork

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In forming scrolls from heavy stock the eye is formed on the anvil and horn. The body of the scroll is formed by using a monkey wrench and bending-fork as shown in Fig. 68. The monkey wrench should have the corners of its jaws filed

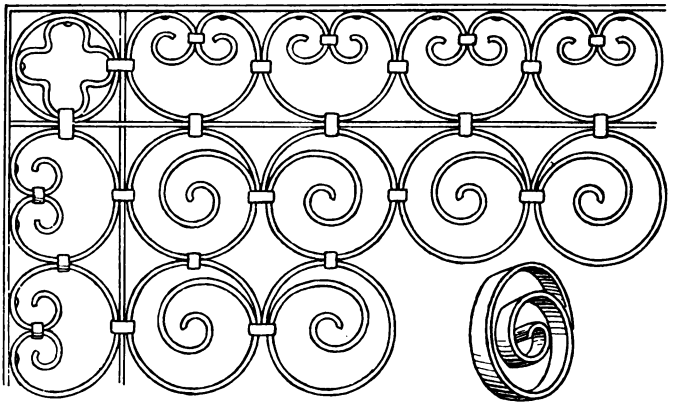

Fig. 72. Design of Grille Corner to be Made from Flat Stock

round in order not to destroy the finish of the bar being formed. After the scroll is formed by pulling it around with the wrench, if there is any part that needs a little rectifying, it may be done on the horn, or if the coil is closely coiled, it may be done by using a large pair of tongs as shown in Fig. 69. In doing this the scroll is heated quite hot and laid on the surface plate. By catching between the coils with the tongs they may be

pressed together, or if they need to be opened or moved in another direction it can be done by pulling out or twisting the handle of the tongs.

In Figs. 70 and 71 are shown grilles which have been worked in the manner described for forming flat scrollwork. Fig. 72 shows a sketch of a corner for a grille to be made from flat stock. The design consists of a frame with the surface divided into nine rectangles. The center rectangle is filled with an ornament consisting of the circle and scroll combined in one and repeating itself throughout the central square. The ornament may be made from one piece of stock or it may be of two pieces. The corner ornament is in the form of a rosette and made of two pieces. The border is filled with a scroll pattern repeating itself throughout. The method of fastening these forms in place is with the band, excepting the outer edge, which is riveted.

In Fig. 73 are shown a number of ornamental forms based on the circle and made from flat stock. Forms from flat stock are very simple to make unless the members are welded. Grille work made of flat stock presents a very pleasing appearance. By viewing the grille from the narrow edge first we get the idea of delicacy. An increasing sense of strength is obtained with the constantly varying profile as viewed at different angles.

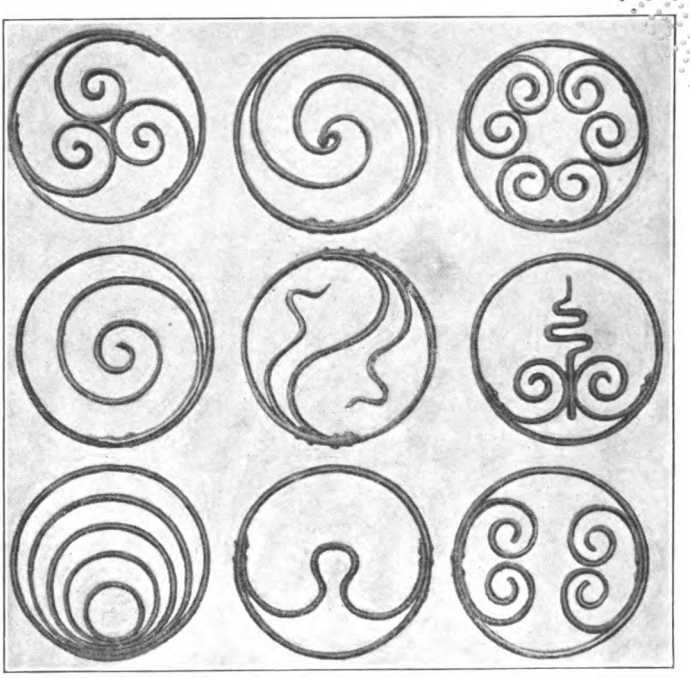

Fig. 73. Ornamental Forms Based on the Circle

In Fig. 74 are shown some drawings of scroll ends which can be used in connection with scroll-work, making it more interesting. The drawings show the ends shaped, also the pieces as they appear before being formed.

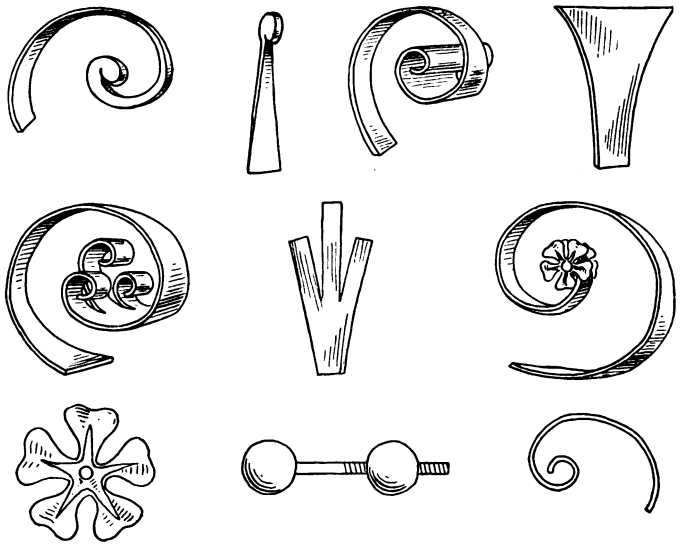

Fig. 74. Scroll Ends

In drilling the holes for rivets to fasten together the different members of a flat scroll, a long flat drill should be used. A slate pencil is used to mark the places for the holes. These are marked first on the edge of the stock, as shown by the

dotted line at A, Fig. 75. The scroll is then pulled or twisted to one side, and the pencil line is carried across the flat surface of the stock and the center marked with a center punch. The holes

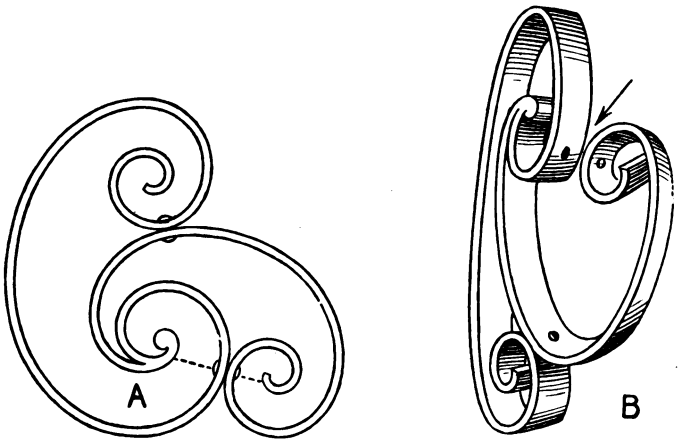

Fig. 75. Method of Riveting Scrollwork

are drilled as shown at B. The scroll is then twisted in line and riveted. Sometimes these holes can be drilled without doing this, especially if the scrolls are coiled loosely.

Welded Scrollwork.—When two or more parts of a scroll are to be united, welding is a most effective means, but this requires considerable skill. Scrollwork that is to be welded may be made from either rectangular or round stock. The principle

of forming the bars into scroll shape is the same as previously described for flat-stock scrollwork.

Say, for example, a piece of scrollwork is to be made from round stock and formed like the drawing in Fig. 76. To make this, one weld is to be made as indicated by the dotted line crossing the bar. The length is found by measuring the parts with a string, starting at the dotted line. The part A is measured and cut plenty long. This piece is also smaller in diameter than the rest of the scroll. It is upset on one end considerably, and the eye is formed by hammering it on the

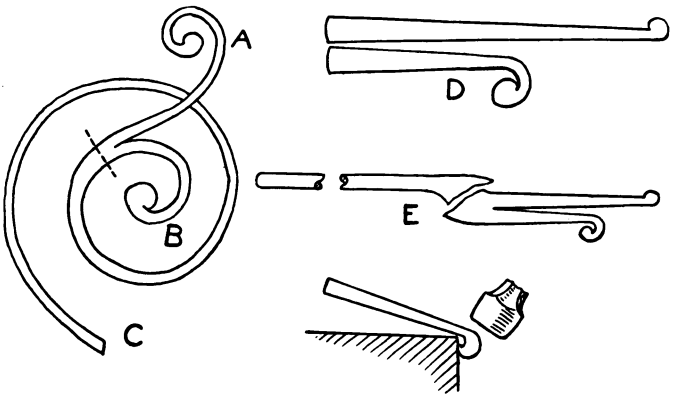

Fig. 76. Method of Welding Scrollwork

edge of the anvil, as shown in the drawing. To find the exact length for this piece it is now measured again and the end cut off and upset for the weld. Part B is treated in the same manner.

The two pieces are now heated to a welding heat and lapped as shown at D, welding them at the end. At the same time they are scarfed. The piece C is now measured and cut. One end is upset considerably and scarfed. A heat is taken

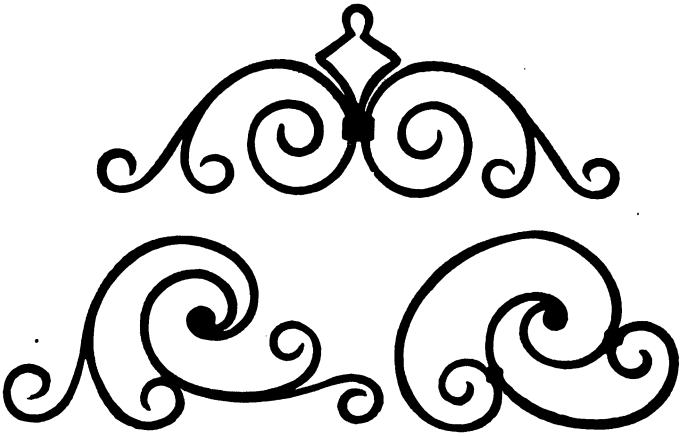

Fig. 77. Flat Stock Welded and Formed into Scroll Shape

on the pieces, lapping them as shown at E and welding. After the weld is made it is smoothed by using the swages. In forming the scroll it is heated at the eye and bent into shape by hammering the bars over the horn of the anvil and also with the bending-fork. Where the bar A intersects bar C they are not halved into one another, but laid side by side. As the scroll is formed into shape it must be tried on the drawing, after working each heat, to see that it fits.

CHAPTER VIII

BOX FORGING

A BOX forging is one that has been formed in the shape of a box, and is generally used for the base of some piece of ironwork. Fig. 78 shows a candelabrum with a box base. A base of this kind is formed from a flat piece of metal by bending the edges over to form the sides, giving it the appearance of stability and yet leaving it light in weight. In forging a base of this kind two methods may be employed: one, where the shank or upright piece is welded to the flat or base part by a jump weld; the other, by forging the shank and base from one piece of metal.

To forge the base from one piece, a round or square bar may be used, either of soft steel or Swedish iron. Common iron will not do, as it is likely to crack while working up the form. The first thing to do is to determine the size of the base and the amount of stock needed. In this kind of forging plenty of stock must be allowed, as it is better to have too much than to be short when finishing the forging. After the stock is cut it is heated and fullered as shown in Fig. 79, at A. The part that is to form the shank is now heated

and drawn out to fit into a square hole in a cast-iron block, or if the shank is to be 1 in. square it may fit the hole in the anvil. The heavy piece shown at B is then heated and the shank inserted

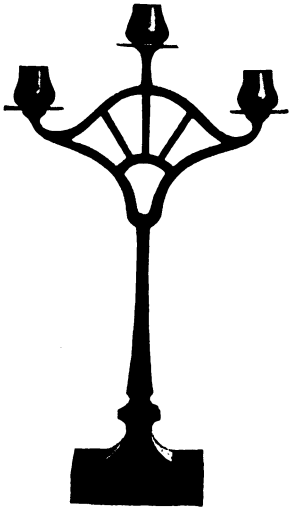

Fig. 78. Candelabrum with Box Base

into the hole in the anvil. With the sledge hammer it is hammered until it is flattened to the desired thickness, in this case about $\frac{3}{16}$ in. It will be necessary to take more than one heat to do this, and, while hammering, the piece must be kept straight. When the part that is to make the base is flattened it is cut square, measuring $5\frac{1}{2}$ in. on

a side, and will appear as at C. The next step is to heat and bend, over a block, 7/8 in. of the edge to form the sides of the base. This is done by hammering them over a block that fits in the anvil. This block is shown at D. To bend the sides one edge of the plate is heated and hammered over the block, then another edge. The corner will now be longer than the side, as shown at E. The extra

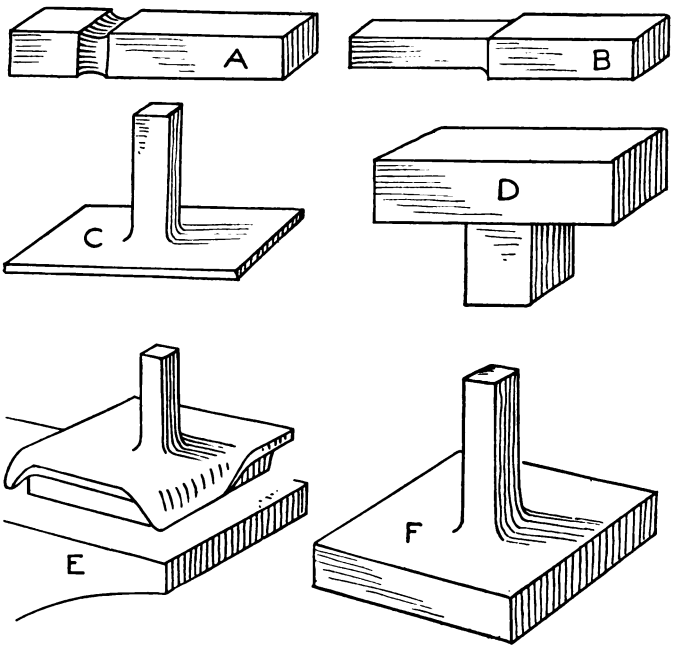

Fig. 79. Method of Forging a Base

length on the corner is cut off with a chisel. A heat is then taken on the corner, and with a lighter hammer it is upset by striking it on each side while the plate is on the block, forcing the metal together until a square corner is obtained. The other edges of the plate are then bent over and the corners squared in the same manner. The base is now ground on an emery wheel to get it level on

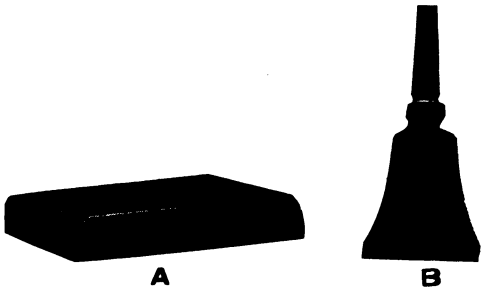

Fig. 80. A—Base for Andiron. B—Base for Candlestick

the bottom and also to get the sides of uniform height. It will now appear as shown at F. Each corner is now heated, and the base is set on the anvil. The corners are then hammered on the top side in order to get them square, and at the same time the sides are hammered so as to keep them straight. After the base has gone through this process of heating and hammering the stock should be about $\frac{1}{8}$ in. thick.

In the forging of this kind of work the main thing to look out for is not to get the corner

cracked. This may be avoided if care is exercised in keeping the work in shape and not letting kinks form in the metal.

Fig. 80, at A, shows a base that may be used

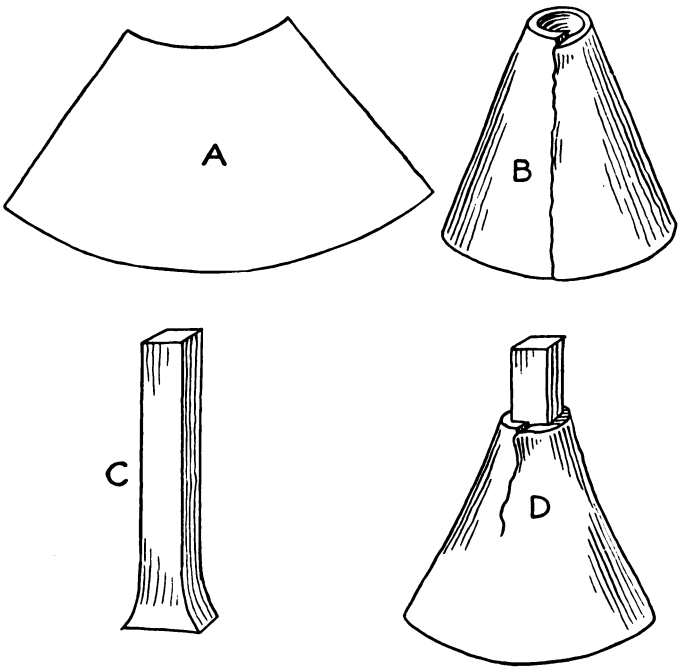

Fig. 81. Method of Making Base for Candlestick

for an andiron. The stock used is a plate of soft steel ¼ in. thick. The base is made by hammering the edges over the square block on the anvil, and the corners are hammered in the same manner as described for the previous base.

At B is shown a different style of base. Unlike the candelabrum, this base is very slender, and the method of forging is entirely different. The cut shows its appearance after the forging operation. It is to be the base of a candlestick, and to finish it properly it must be ground on an emery wheel and also smoothed with a file. The base consists of two pieces welded together, and is made by first cutting, from a plate of soft steel $\frac{1}{8}$ in. thick, the form shown at A, Fig. 81. The ends are then scarfed and the pieces bent over the horn of the anvil in the form of a cone, as shown at B. A heat is now raised, welding down the laps excepting at the small end of the cone. This is hammered square, having the lap between two of the corners. A piece of 1-in. square iron is then cut 5 in. long and upset on one end as shown at C. The square piece is driven into the cone as shown at D. The cone is caught at the bottom with a pair of tongs and placed into the fire so as to get a heat at the top end of the cone; the joint is fluxed and the heat raised, welding the two parts by hammering them square. The top or swelling in the shank, as shown in the cut, is formed by fullering each side of it. When this is done the stock above is drawn to the desired size.

Fig. 82 shows a two-light candlestick with the base fastened to the upright piece not shown. The base is made from $\frac{1}{8}$-in. thick soft steel. It

Fig. 82. Two-Light Candlestick

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is heated and hammered over the edge of the block, bending it to an angle of 45 degrees. When this is done the corners are hammered square, at the same time giving it the concave form as shown in the cut. When finished it is fastened with countersunk-head screws.

CHAPTER IX

EMBOSSING

BY embossed work is meant the modeling of forms in relief on the surface of sheet metal. This is done by hammering the metal on a substance which will give some resistance to the blows. Simple tools are used in the operation. For iron-

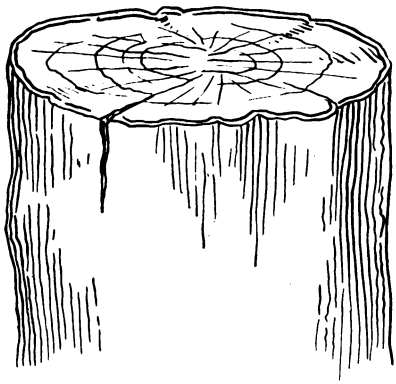

Fig. 83. Block Used in Embossing

work, wood and lead are used as an anvil to hammer on. It requires considerable practice and some knowledge of drawing and modeling to do good embossed work. Leaf and other ornamental

forms are used as embellishments in some designs for ironwork. Nowadays many of these are made with dies, but with this method, it is needless to say, the exactness and sameness of the work de-

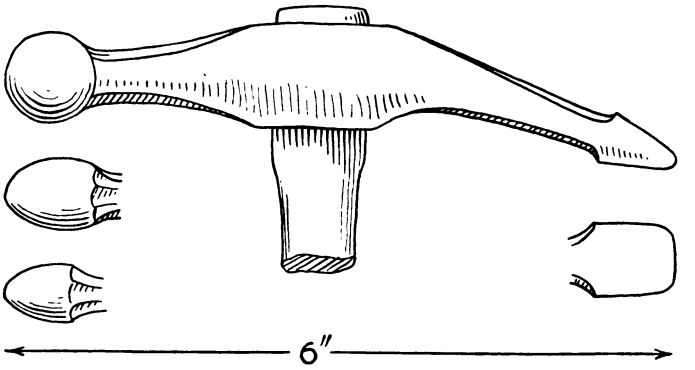

Fig. 84. Modeling-Hammers

stroys all the artistic beauty and reduces it at once to the commonplace.

In Fig. 83 is shown a block of elmwood suitable for hammering metal on when raising and embossing it. The block should be about 3 ft. high and 12 in. in diameter. It is well to have several blocks of various sizes.

The method of raising projections on the surface of metal is to heat the metal and set it while hot on the end grain of the block, where it is hammered. The wood will burn faster at the place

being hammered and force the metal into the depression, thereby raising that part in relief. After the form is raised as much as needed in this manner the work is allowed to cool. A piece

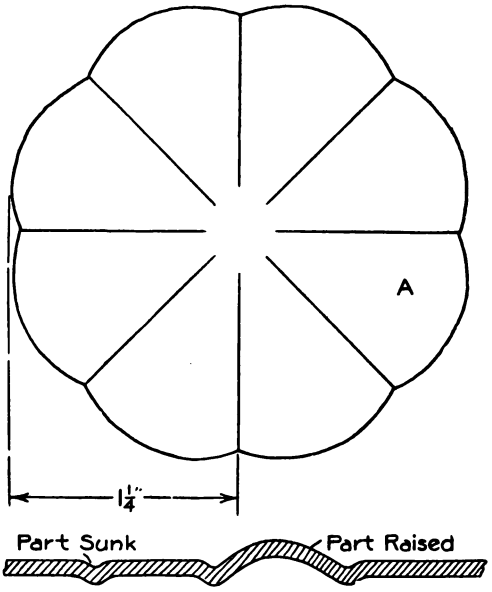

Fig. 85. Design for Modeled Rosette

of lead about 6 in. long, cut from a pig, is now used as an anvil on which to hammer the metal. The metal when cold is hammered on the lead in order to work up more detail and to true the piece. Constant hammering on lead while the metal is cold makes it brittle, and as the work

progresses it must be annealed. To do this it is heated red and allowed to cool slowly.

Modeling-hammers of various sizes, as shown in Fig. 84, are used for embossed and raised work. The balls and peens should be smooth; in other parts they may be forged roughly. Special tools are needed at times, and as one becomes a little more acquainted with the work he can readily make a tool that will be of service in forming some particular part. The stock used is generally soft steel or Swedish iron. If the work requires a great deal of hammering it is advisable to use an extra grade of steel, the kind used for stamping, spinning and drawn designs. The thickness of the stock depends on the character of the work wanted. For light work No. 18 or 20 is about right. For heavy work, however, the ornament should not be delicately modeled in the metal, but must be boldly hammered from sheets at least No. 14 or 16 gauge.

Rosette.—As an example a simple rosette is shown in Fig. 85 at A. To relieve the monotony of its surface it is modeled. The stock may be No. 18 or 20 common soft steel. It is first cut from the sheet with a curved chisel. The part between the straight lines is to be hammered from the under side. In doing this a tool as shown in Fig. 86 is used, which will be referred to hereafter as a sinking-tool. This tool is made from a piece

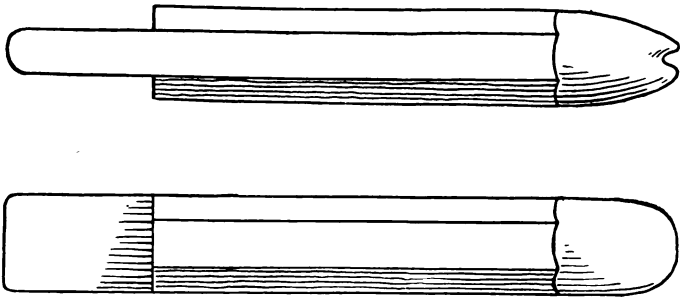

Fig. 86. Sinking-Tool

of ¾-in. square or hexagonal tool steel. The sink at the top is filed smooth without any sharp corners and is about $\frac{3}{16}$ in. wide and half as deep. The tool is to be caught in a vise. A top tool is also used, to fit into the sink in the lower one. This tool is shown in Fig. 87. It is simply a small

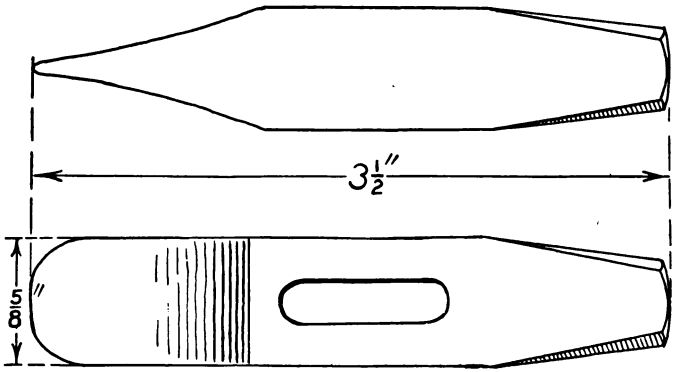

Fig. 87. Top Tool

fuller, made from a piece of tool steel, and with a hole punched for a wooden handle. The bottom part is filed rounding, without any sharp corners. It should fit freely into the sink in the lower tool.

In modeling the rosette, straight lines are drawn with a slate pencil on the surface of the plate as

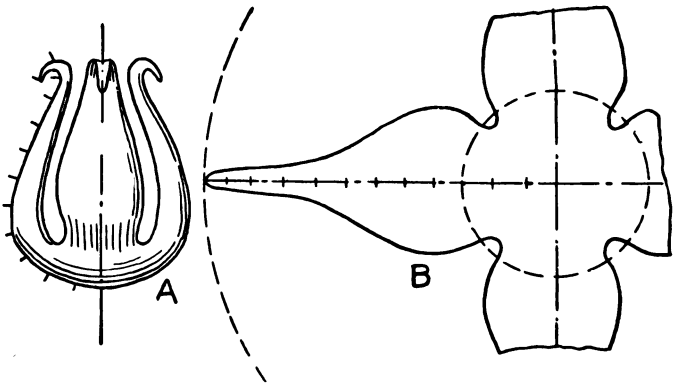

Fig. 88. Modeling a Bulb

shown in the drawing. The plate is then set onto the sinking-tool with the slate-pencil lines up and directly over the sink. The top tool is set onto a line, starting at the outer edge. A helper strikes the tool with a hand hammer, forcing the metal into the sink, and at the same time the plate is moved toward the center. Each line is sunk in this manner. The lines may also be sunk with the modeling-hammer by hammering them into the

sink with the peen. The plate is now heated to a black heat, and the part between the sinks raised by hammering on the under side of the plate. The ball and peen of modeling-hammers are used to do this, and the rosette is set onto the lead while hammering.

Modeling a Bulb.—In Fig. 88, at A, is shown a conventionalized four-petal flower which may be used as another example in explaining the method of modeling this kind of work. The stock used may be No. 18 or 20 soft sheet steel. The first thing to do is to develop a pattern on paper. In doing this the length of the outer curve from the center to the point of petal is found by stepping it off with equal paces, using a pair of dividers. A straight line is then drawn and crossed by a right-angle line through the center. The number of spaces found by stepping around the petal are laid out on this line, giving the stretch-out of the petals. The shape of the petals may now be sketched in as shown at B. It is not absolutely necessary that the petals should be laid out exactly like the drawing. The pattern when finished is cut out and laid onto a sheet of metal, scribing around its edges onto the metal; $\frac{3}{16}$-in. holes are then drilled to form the loops, the rest is cut out with a narrow chisel, and the edges filed smooth. The piece is now heated and the petals formed by hammering them on the end grain of the block.

Each petal is hammered; then the center is heated and hammered on the inside, bringing the points up. The work is allowed to cool and then trued by forming it over the end of a round bar of iron

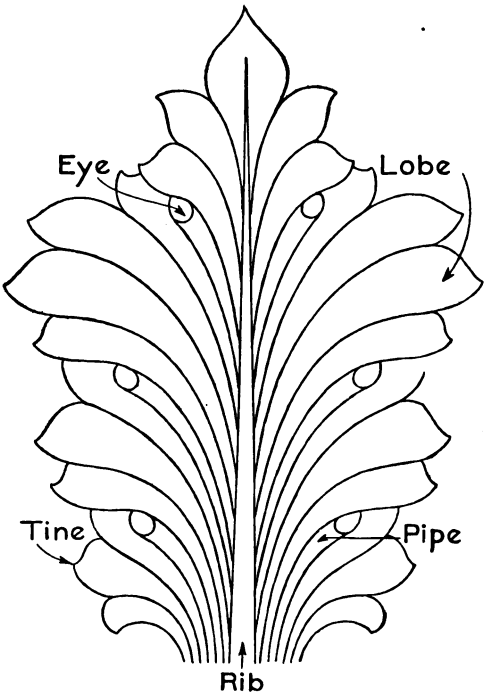

Fig. 89. Essentials of an Acanthus Leaf

which has previously been rounded at the end to conform with the shape of the bulb. When this is done the points are bent over as shown in the drawing.

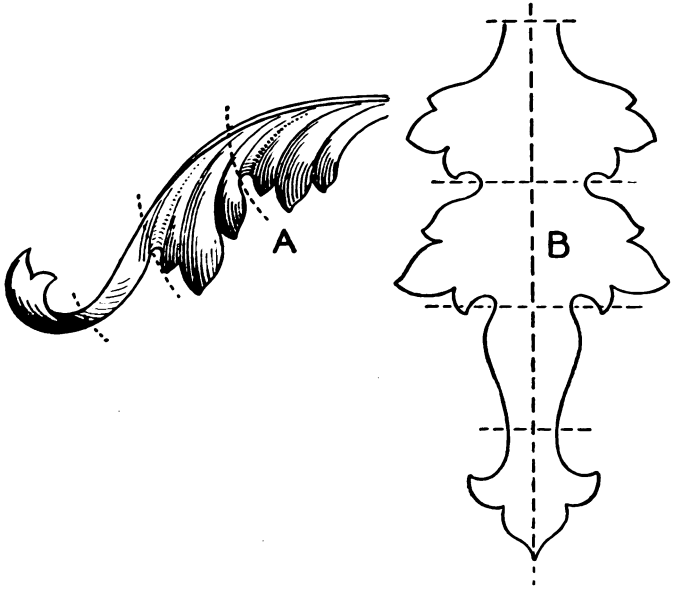

Fig. 90. The Acanthus Leaf as Modeled and Also as It Appears in the Pattern

Acanthus Leaf.—The acanthus leaf is generally modeled from sheet metal about No. 20 or up to $\frac{5}{32}$ in. in thickness. After it is modeled it is welded to the bar it is to ornament. It may also be fastened in position with rivets, or brazed. Welding, however, makes the most effective job, although it is sometimes difficult. The essential parts of the acanthus leaf are shown in Fig. 89.

The execution of hammered foliage from sheet metal requires artistic intelligence, ingenuity and

skill in the use of simple tools. Before hammering up the acanthus leaf in metal a drawing is first made showing the leaf as it would appear when finished, and then another showing the shape of the leaf before it is modeled—that is, a developed drawing of the leaf as it would appear flattened after being cut from the sheet without working in any manner. It is hardly possible to lay this out exact, nor is it necessary, as it will work up in a satisfactory shape if the general dimensions are correct.

In Fig. 90, at A, is a drawing of a leaf as it will appear when modeled in metal; at B the same leaf is shown as it would appear when flat-

Fig. 91. Modeled Leaf

tened, or the drawing to be used for the pattern. To develop this pattern its length is found first. This is done by stepping along the rib of the leaf

with equal spaces, using a pair of dividers. The number of spaces found is now laid off on a center line on the pattern giving the length or stretch-out of the leaf. The dotted lines across the leaf are drawn to locate the eyes of pipes and

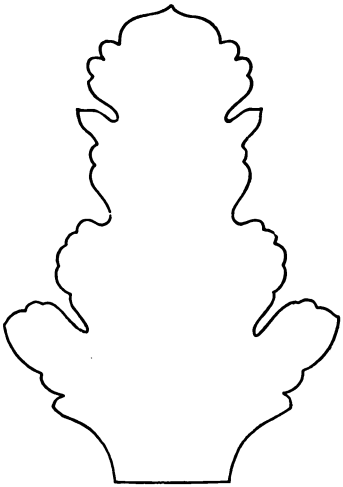

Fig. 92. Pattern of Leaf Shown in Fig. 91

indentations along the edge. The distances from the top of the leaf to the dotted lines are located with the dividers, and horizontal straight lines are drawn on the pattern corresponding in distance to the dotted lines on the leaf. The width

Fig. 93. Truing-Tool

of the leaf from the eyes to the rib is now measured along the dotted lines, allowing a little extra for the bend of the leaf. The distance found is then laid out on the horizontal lines on the pattern. The general shape of the leaf may now be sketched in and the pattern cut out.

Fig. 91 shows a leaf modeled from No. 20 soft steel, and Fig. 92 shows a drawing of the same leaf flattened before it is hammered in any way. To model this leaf it is heated red and with the ball of a good-sized modeling-hammer it is hammered on the end grain of the block to give it the general shape. It is then annealed, and when cold the rib and pipes are raised. To do this they are sketched on the under side of the leaf with a slate pencil and then hammered in a sinking-tool with a sink about $\frac{1}{4}$ in. wide and a scant $\frac{3}{16}$ in. deep. The leaf is set onto the tool with the pencil marks up and directly over the sink. With the peen of the modeling-hammer the metal is driven into the sink, starting at the top of the leaf and continuing for a distance of two-thirds of its length. A smaller sink is now used to raise the rest of the rib. The pipes are next raised, starting with the large sinking-tool at the eye and using the smaller one as the pipe nears the rib. The lobes or leaflets are next raised. This is done on the lead block by hammering from the under side of the leaf with peen and ball of hammer. The sinking-tools are

also used to hammer on, working depressions from the top of the leaf into the sink with the hammer. After the leaflets are raised the ribs and pipes are trued by setting them onto a tool as shown in Fig. 93. This tool, which is to be caught in a vise, is simply a chisel ground rounding across the face. The rib of the leaf is straightened by setting it onto this tool, top part up, with the peen of the hammer. The edge of the rib is held against the side of the tool and struck with the hammer, and at the same time the leaf is kept moving along the tool. As the end is neared the rib is made a little narrower, gradually letting it taper to a point. The pipes are trued in the same manner, letting them taper to a point as the end is reached. They are also tangent to it.

Fig. 94 shows an ornamental piece of scroll-work with the acanthus leaf welded in position. In welding on leaves, the bars should be bent the same shape as the leaves for a distance equal to the length of the leaf. The reason for this is that the bar under the leaf cannot be formed very well with the leaf attached. Another reason is that the leaf will hug the bar and keep its shape while getting the heat. When the leaf is welded the rest of the scroll is formed. To weld a leaf the top part is hammered around the bar and the whole placed into a small fire. The leaf and bar are caught with a pair of tongs that fit the work

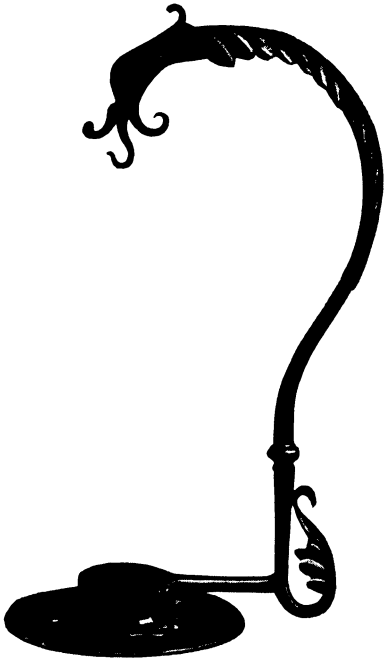

Fig. 95. Frame for Teakettle and Burners

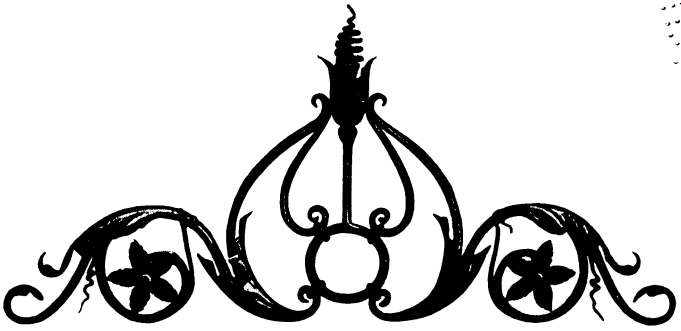

Fig. 94. Acanthus Leaves Welded in Position

so that one jaw will bear on the leaf and the other on the bar. The blast is turned on slowly, bringing the whole to a red heat. A little flux is then put onto the top part of the leaf and the heat

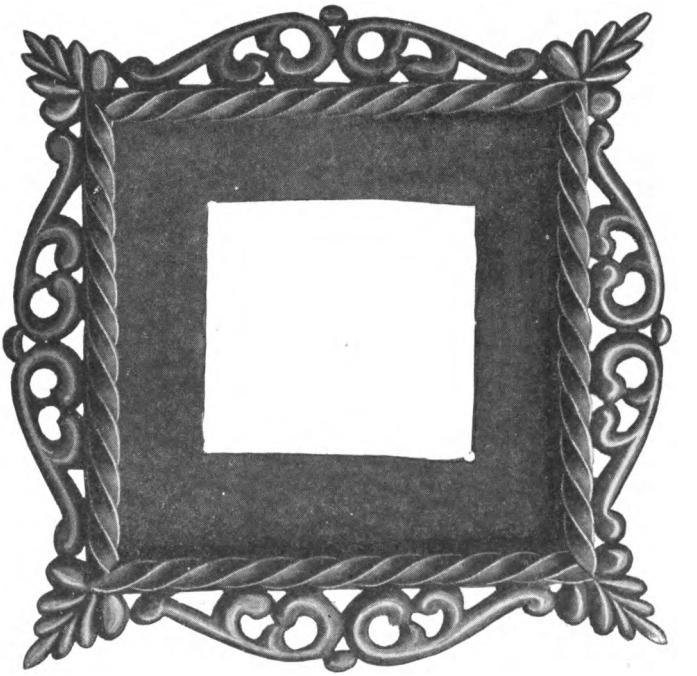

Fig. 96. Border for Marble Table-Top

raised. It is welded on the anvil horn with a small hammer. In raising the heat to the welding point care must be taken not to burn the tines of the leaf.

Fig. 95 shows a frame to hold a teakettle and burner. This is an example of forged and welded work. The disk at the bottom is made from sheet brass.

Fig. 96 shows a top for a stand or table which is to receive a marble slab between the twisted molding. The molding is fastened to the top with countersunk rivets. The top is first pierced with chisels and hammer; it is then filed and hammered on wood and lead to model it. The opening in the center is cut out in order to allow the sheet to straighten; otherwise it would be winding and could not be straightened.

Fig. 97 shows leaves and a rosette hammered from sheet metal and also a leaf with the stem attached and forged from a heavy bar. This is forged by flattening heavy stock and then cutting out the shape of the leaf. It is modeled afterward. A spray of leaves is also shown, based on the growth of the thistle. The leaves are forged separately and welded to a stem.

In Fig. 98 are shown three rosettes that have been hammered from No. 20 soft steel. The one in the center consists of three pieces and is to be fastened in position with a bolt, the head of which is covered with the bulb in the center.

Raised Forms.—If a disk of sheet metal is heated and hammered over a depression in a block of wood, its edges will turn up in the form of a

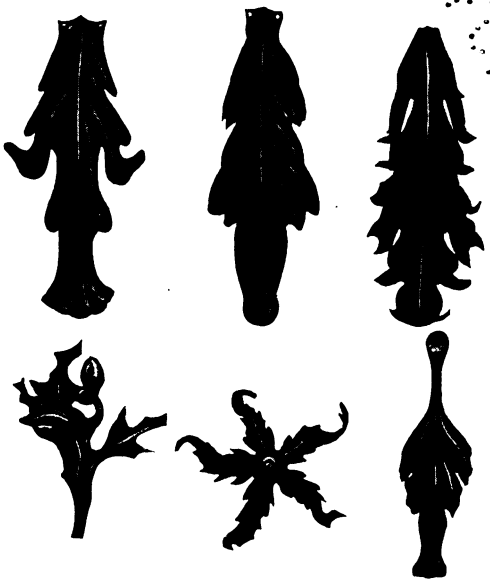

Fig. 97. Leaves and Rosette

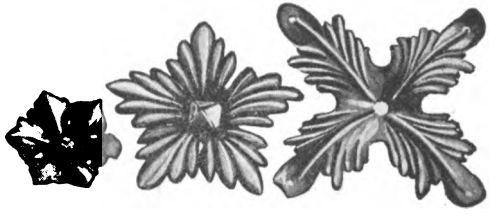

Fig. 98. Rosettes

dish. If the operation is continued the metal will become hemispherical in form. The metal used should be soft steel from $\frac{1}{16}$ to $\frac{3}{16}$ in. thick.

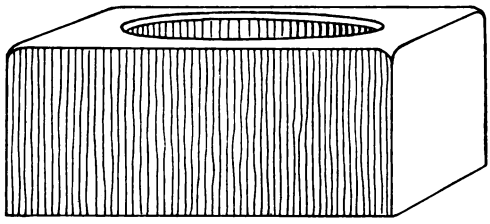

Fig. 99. Cast-Iron Block Used in Making Raised Forms

Fig. 99 shows a block of cast iron which has a hole through it countersunk at the top. This may be used to raise the form on. The method of raising a form is to heat the sheet and hammer it over the hole in the iron block, starting by hammering around the edge with a series of blows until

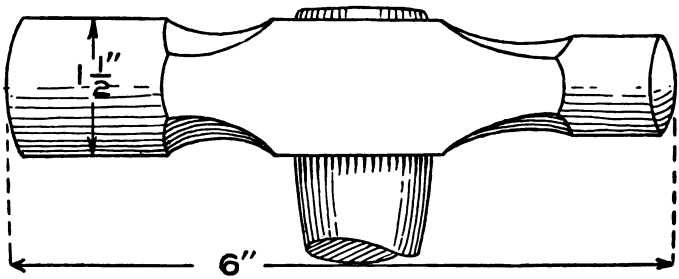

Fig. 100. Hammer Used in Raising

the center is reached, using a hammer as shown in Fig. 100. The operation is continued until the piece is raised as much as desired. The edge will be more or less uneven when finished and must be

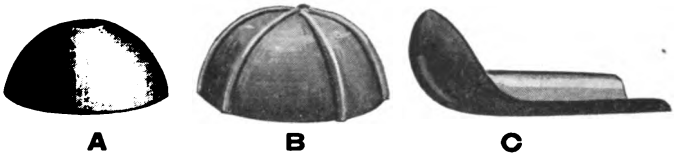

Fig. 101. Raised Forms

trued with a file or emery wheel. The work should also be tried on a surface plate to see that it is level.

At A, Fig. 101, is shown a form that was raised on the iron block, and at B is shown another which has six ribs, radiating from the center, which were made with the sinking-tool. These hemispherical forms may also be enriched by bumping up their surface with relief ornaments. These pieces are to be used as ceiling canopies to cover the electric wiring for hall lanterns. At C is shown a shovel bowl which has been raised on the wooden block. The pattern is shown in Fig. 102. The stock used is No. 16 soft steel.

Metal is sometimes raised by bumping it into an iron form. If a series of bumps of the same size and shape are needed it may be well to ham-

mer the shape into an iron block while hot; then heat the plate and hammer the metal into shape.

The projections at the corners of base on the candlestick shown in Fig. 103 were bumped into a shape made in an iron block. A hole was first drilled into the block; it was then heated and a punch of the proper shape driven into the hole. The candlestick base was heated and the corner hammered into the hole.

A candlestick and two match-receivers are

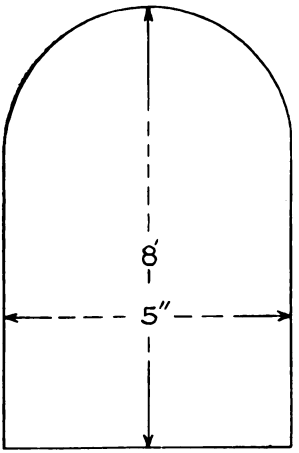

Fig. 102. Pattern of Raised Form C in Fig. 101

shown in Fig. 104. The square match-receiver is fastened on the corners with No. 12 round-head rivets. It is riveted to the base. The stock is No. 20 soft steel. The elliptical receiver is made by

bending a piece of No. 20 soft steel in cylinder shape, letting the edges butt together. It is then brazed with spelter; afterward it is formed ellip-

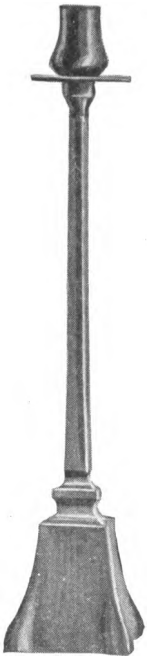

Fig. 103. Candlestick with Raised Projections at Corner of Base

tical. The bottom is fitted and brazed. To fasten receiver and base together $\frac{3}{8}$-in. square stock is used.

The base of the candlestick is round, with the stem riveted into it. The socket to hold the

candle is bent round, butting the edges together and brazing them. A bottom is fitted in and brazed with spelter. This bottom, projecting all around, forms the drip pan. It is riveted to the stem. The surface of the candlestick is chis-

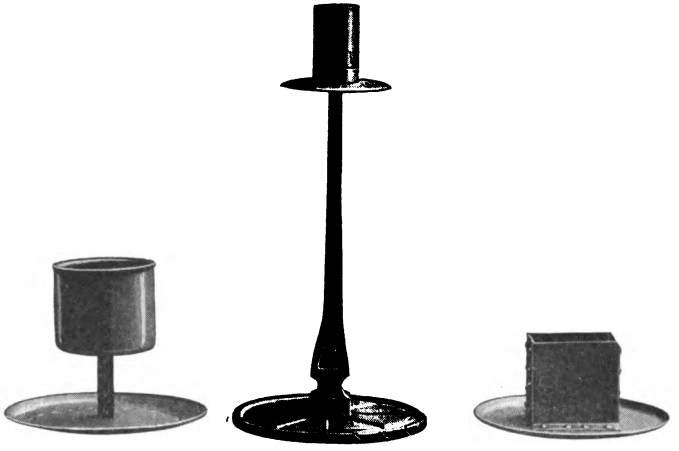

Fig. 104. Candlestick and Match-Receivers

eled as shown in the illustration. The stem and base are cut while the metal is hot, and the socket and drip pan when cold.

Finish.—Interior ironwork should never be painted or covered with electric plating. If covered with a coating the article might just as well be made from wood or some other material, as from wrought iron. Ironwork must be seen as

such. About the best treatment it can receive in the way of a finish to keep it from rusting is to burn oil on it. If the piece is a large one the different parts may be treated before they are fastened in position. In burning oil on ironwork the piece is held over the fire until a black heat is reached—it must not be a red one. It is then taken out of the fire, allowed to cool a little, and linseed oil is rubbed over it with a rag. The oil must be put on thick enough so that the heat from the piece will not burn it. The piece is then dried with a clean cloth and allowed to cool.

To clean ironwork after it has been in use for some time the piece is carefully dusted, and then it is gone over with a rag and thin oil. Machine oil is good. It is then dried and polished with a clean cloth.

Ironwork that is exposed to the weather must have a coating of some kind in order to exclude the moisture and keep it from rusting. The color should be black, and either paint or asphaltum may be used.

CHAPTER X

DRAWER-PULLS AND HINGES

A DRAWER-PULL generally consists of a plate to which a handle is fastened. The handle may swing from one or two points, or it may be fastened to the plate with rivets, making it immovable. The plate may be ornamented by piercing or embossing, or both. The ornament may also be cut on the surface with tools, leaving it sunken into the metal. The stock for handles may be round, rectangular or irregular forged shapes.

Fig. 105 shows a drawer-pull with the dimensions. This is a very simple pull, with a movable handle—that is to say, the handle must be raised before the drawer is pulled out. The handle is fastened in position between the lugs with rivets, allowing it to be raised and lowered. The plate is to be fastened with countersunk or round-head screws.

In constructing the pull the plate is made first. The shape of the plate is first sketched on a piece of soft steel with a slate pencil as shown by the dotted lines in Fig. 106. The piece is then marked by cutting on the slate-pencil lines with a cold

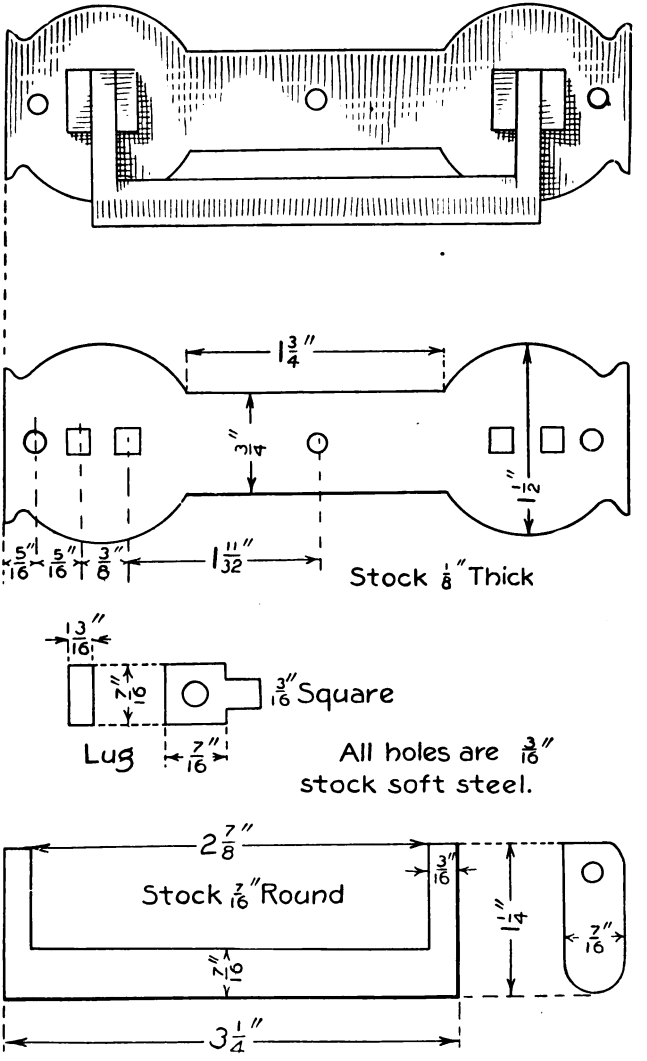

Fig. 105. Detail of Drawer-Pull with Movable Handle

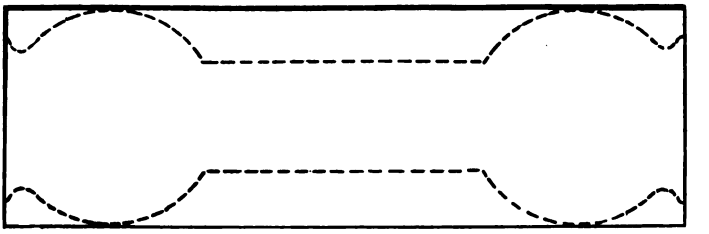

Fig. 106. Outline of Plate of Drawer-Pull

chisel, after which it is heated and cut from one side by using flat and curved chisels. The edge is smoothed with a file, and all the holes are drilled. The holes for the lugs are made square by driving a square punch into them. It is well to rub a little oil on the punch before using, as this will allow it to be released easier. The lugs are next made and placed into the holes which have previously been countersunk on the back of the plate. The lugs are made tight by hammering, and afterward ground or filed smooth. The holes are also drilled in the lugs to fasten the

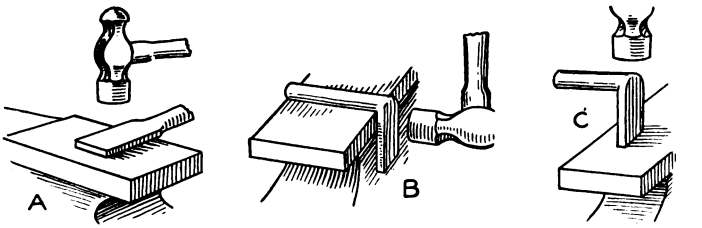

Fig. 107. Making the Handle of a Drawer-Pull

handle. The handle is next made. This is done by heating the bar and hammering the ends flat on the inside of the anvil, as shown in Fig. 107, at A. It is next bent over the outside of the anvil, as shown at B. The corner is now worked square

Fig. 108. Drawer-Pulls with Ring Handles

by hammering in the position shown at C. When the handle is forged, it is placed in position between the lugs and marked, the holes are drilled, and it is fastened with countersunk-head rivets.

Other kinds of drawer pulls are shown in Fig. 108. The rings or handles swing from one lug and are made from square and round stock. Twisted and simple ornaments are cut on the surface with chisel tools, both on the rings and

plates. These pulls are to be fastened in position with round-head screws. The stock used for the plates is $\frac{1}{16}$ in. and $\frac{1}{8}$ in. thick. The $\frac{1}{8}$-in. stock is drawn thinner on the outer edge with the hammer. The lug that the rings are fastened to

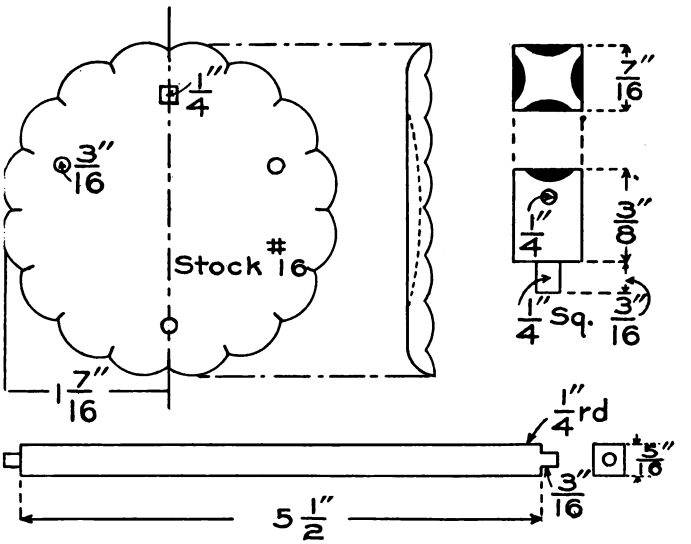

Fig. 109. Drawing for a Pull with Scalloped Plate

is riveted onto the plate. In doing this a square hole is punched in the plate and countersunk on the back. After the lug is riveted it is dressed smooth with a file or grinder. The rings are first twisted; then the tenon is filed round at the ends. They are then heated and formed and may be sprung onto the lug while hot.

Fig. 109 shows a drawing for a pull. The edge of the plate is scalloped. This is done when it is cut from the sheet, and a curved chisel is used for this purpose. The scallops also turn up a little.

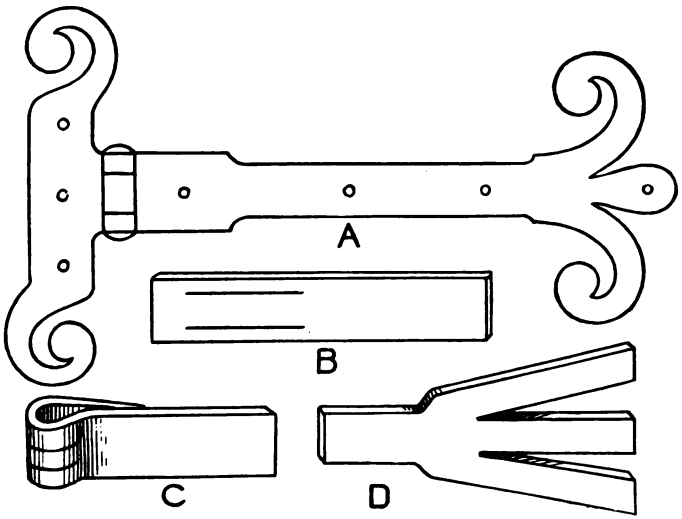

Fig. 110. Drawing for a Hinge, with Method of Forming

This is effected by heating the plate and stretching the stock a little between the scallops with a hammer and small fuller. The center of the plate is domed out a little by hammering it on the back with a modeling-hammer.

Hinges.—In Fig. 110, at A, is shown a drawing for a hinge that may be made from heavy

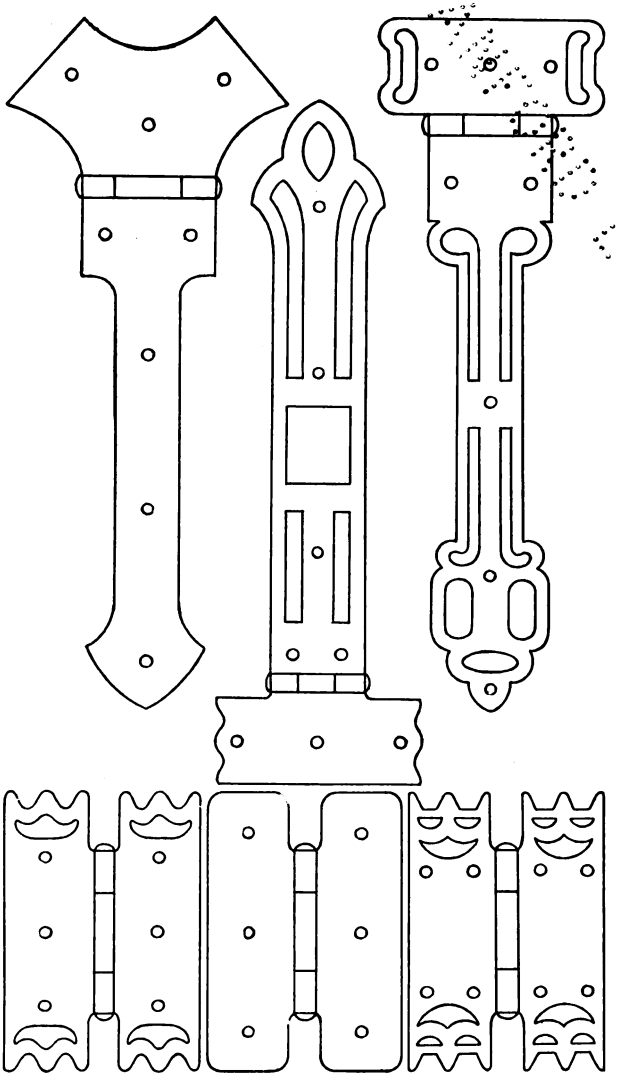

Fig. 111. Hinges of Various Forms for Furniture, Etc.

stock, having the eyes that form the joint welded. After the size of the hinge and the strength is determined, the eye for the joint is turned and welded. To do this the stock is heated on one end and hammered on the flat part until it is drawn sharp. The eye may then be formed and welded, cutting out the stock between the projections with a saw and chisel. The projections will then fit into the projections on the other half of the hinge, allowing a pin or rivet to pass through the eyes so that the hinge will swing. The width of the projections on one leaf should equal the width of the projections on the other. The length of stock necessary to form the eye of the hinge is three times the diameter. Another method of forming the eye is to hammer the end of the bar sharp. The quantity of stock for the eye is then found, and the bar heated and split through from one side with a thin hot chisel. The length of the splits is the same as that required for the eye. See B, where a bar is shown split and ready for the eye to be formed. Note that the splits are not run to the end. The reason for this is that after the eye is turned this part is to be welded to the bar. (See C.) After it is welded and the eye hammered into shape the center part between the splits is cut out with a long, slim hot chisel, leaving two projections on the leaf. The other leaf of the hinge is formed and welded in the same

manner. Instead of the center being cut out, it is left on, and the part on each side of it is cut off. In making this part of the hinge, a T weld is made with two pieces of stock; then the eye is formed and welded. The stock for the scroll ends is first drawn out on the horn of the anvil, and then the scroll is formed in shape. The tail of the hinge is formed from a piece of wider stock and then welded to the bar that has the eye on. The tail is made by splitting the stock into three parts as shown at D. The center part is cut shorter than the outside pieces. These prongs are then formed into shape.

Fig. 111 shows some hinges that may be made from stock $\frac{1}{16}$ or $\frac{1}{8}$ in. thick. The eyes are not welded, but turned loose, and the projections are then filed. The open or pierced work is first drilled, then cut out with a small, narrow cold chisel.

In Fig. 112 are shown door-keeps and hinges. The stock for the plates is $\frac{1}{16}$ and $\frac{1}{8}$ in. thick. The door-keep at A has a handle which swings from a pivot. The pivot is to go through the door and has a piece fastened to it with a set screw. This piece holds the door, and when the handle is turned the door is released. The keep at B may be used either for a door or window fastener. The latch has a spring so that it will snap when the door is closed.

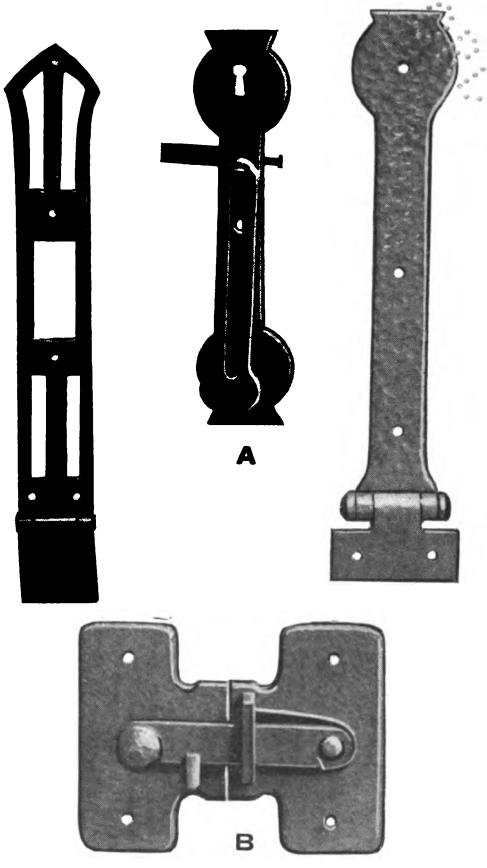

Fig. 112. Door-Keeps and Hinges

CHAPTER XI

DOOR-PLATES

IN Fig. 113 is shown a set of plates for an outside door. The set consists of an escutcheon plate, which holds the lock, an electric-bell plate, two corner-hinge plates and a center-hinge plate. The plates are to be fastened with round-head screws. The escutcheon plate on the inside of the door may be bronze or brass. In making a set of plates the thickness of the door must be known, so that the latch may be made the proper length; also whether the door swings to the right or left, so that the handle on the escutcheon may be bent toward the hinge side of the door. This will give more room between the casing and handle, and the door can be opened more readily.

Fig. 114 shows the drawings and the dimensions for these plates. The lock used is an ordinary front-door lock. To construct these plates they are first cut to dimensions. The corner plates may be cut from a sheet 10 in. wide, and when all are cut they are ground and filed on the edge. A paper pattern is made for the leaf ends of plates, and this pattern is held on the edge of the plates, marking around it with a slate pencil. The pencil

marks are re-marked with a narrow cold chisel, cutting into the metal. Holes $\frac{5}{32}$ in. are drilled for the eyes of pipes, and also a hole each side of the leaf where it springs from the plate, as indicated at A.

The leaf is now heated and cut through from one side with curved and straight chisels, leaving a beveled edge. This should be the front of the plate. In doing this kind of cutting it is well to have a piece of iron under the work to prevent cutting into the anvil. When all the leaf ends are cut and smoothed with a file, the molding along the edge of the plate is raised. This is done with a tool as shown in Fig. 115, at A—a square block of soft steel which fits the square hole in the anvil. It has a small sink $\frac{1}{4}$ in. wide by $\frac{1}{8}$ in. deep, as shown in the drawing. A hole is drilled at the side of the sink and a piece of round iron driven into it. This is used as a gauge for the edge of the plate to slide against while raising the molding. The top tool is just a small fuller that fits into the sink. There should be no sharp corners on these tools, but they must be smooth.

The plate is heated along the edge, and is then set into the bottom tool with its edge against the pin. The top tool is then placed on top of the plate, directly over the sink, and a helper strikes it with a heavy hand hammer, driving the fuller down and forcing the metal into the sink. At

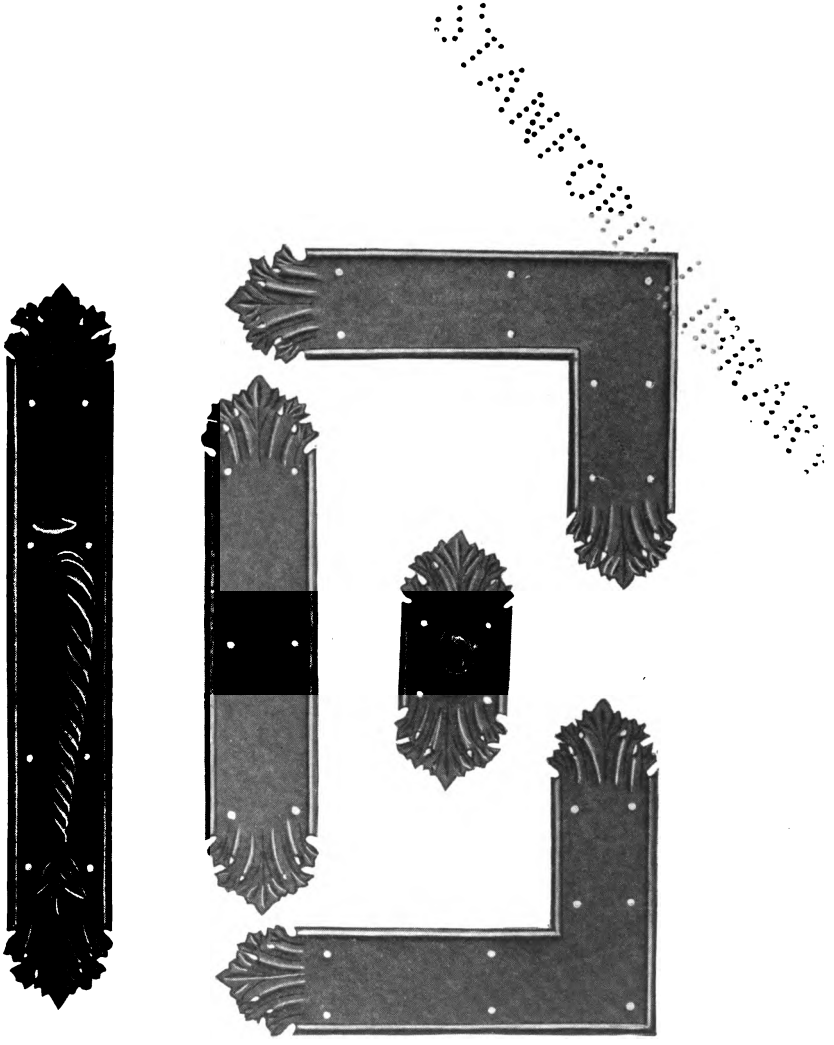

Fig. 113. Plates for an Outside Door

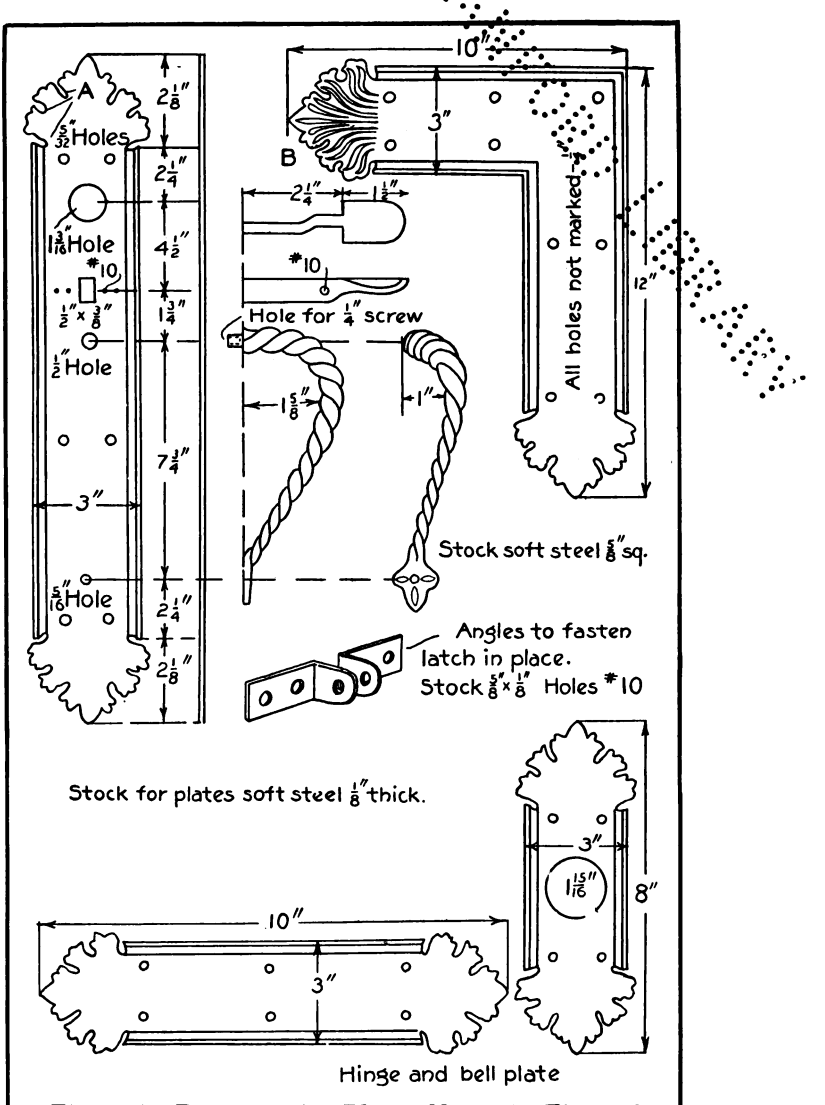

Fig. 114. Drawings for Plates Shown in Fig. 113

the same time the plate is kept moving. (See B.)

When the molding is raised, the leaf ends are shaped as shown at B on drawing, Fig. 114. To do this the plate is heated and the pipes are raised

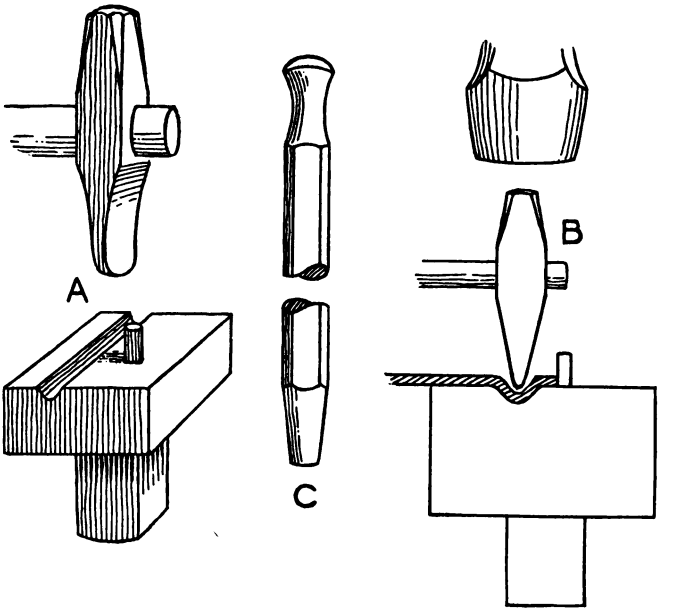

Fig. 115. Making a Door-Plate

with the sinking-tool as previously described for the acanthus leaf. When this is done the lobes, instead of being raised, are sunk with a veining tool as shown at C, Fig. 115. The veins are first marked with a chisel; afterward the leaf is heated and the veining tool is driven into the metal, mak-

ing the insertion deeper at the front of the lobe. After all the leaf ends are finished in this manner the plates are heated and laid on a surface plate with the face up. They are then hammered with a wooden mallet to straighten them. All of the holes are drilled and the angles are riveted to the back of the escutcheon plate. The latch is next forged, and a hole drilled as shown in the drawing. It is then inserted into the square hole of the escutcheon, and a rivet is put through angles and latch.

The handles are forged from $\frac{5}{8}$-in. square soft steel. The bottom part is the first forged, and it is veined as shown. The stock is drawn on a taper and twisted. The length is found by measuring with a soft wire. A $\frac{1}{2}$-in. tenon is swaged at the end. The handle is formed by heating the top part and bending it over a piece of hard wood, using a wooden mallet to hammer with. The handle is now riveted to the escutcheon. A rivet is used in the bottom part, and the tenon at the top is riveted into the plate from the back. A hole is drilled and tapped into the tenon for a $\frac{1}{4}$-in. countersunk-head screw. This is done to help fasten the plate onto the door. The screw is run through the door from the inside into the handle.

CHAPTER XII

IRON LAMPS

IN Fig. 116 is presented an electric lamp with a six-section shade and three chain-pull sockets. Opalescent glass is fastened under the shade.

Fig. 116. Electric Lamp

To construct this lamp the shade may be first made. For this a pattern is developed for one of the six sections. In Fig. 117 are shown the draw-

ing, with dimensions, and the method of developing a section. The plan is drawn full size on heavy paper. For the elevation, vertical projection lines are drawn from the plan. A horizontal

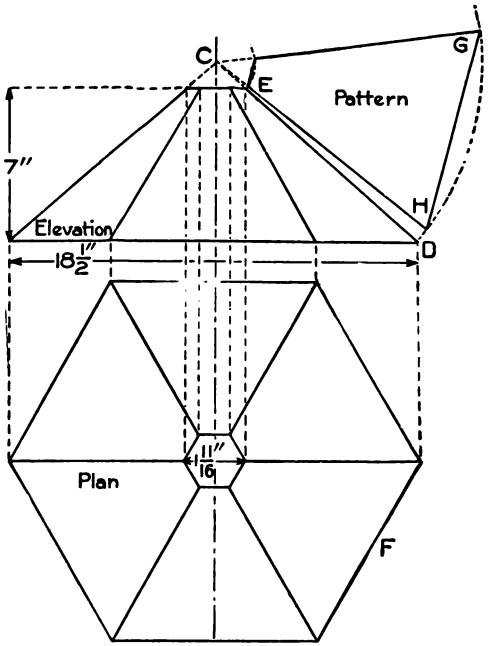

Fig. 117. Drawing for Shade of Electric Lamp

line to form the base of the elevation is drawn above the plan and through the projection lines. Seven inches higher another horizontal line is drawn to form the top of the elevation. The elevation is complete when oblique lines are drawn

from the base line and intersecting at the point C. With one leg of the compass on this point an arc is described with a radius equal to the distance from C to D. Another is described with a radius equal to the distance from C to E. A line the length of F is now drawn from G to H, and lines are drawn from G and H to the point C, also the line E. The space inclosed by these lines is the pattern which should be cut out.

The paper pattern is laid onto a sheet of No. 20 soft steel, marking around its edge with a slate pencil on the metal. The plate is then cut out with a thin cold chisel, and the edges are filed to get them straight, and also to make the plate the same size as the pattern. The other sections of the shade are made by using the first as a pattern.

The design is now sketched on one of the sections with a slate pencil. In Fig. 118 a section of the shade is shown with the design cut out in the form of a stencil. The *motif* is a tree. This may be used, or some other form may be substituted. Perhaps it is best to draw the design on paper, cutting out the open work. This pattern may then be laid on the sections, marking around the edges of the design on the metal with a sharp scratch awl or pencil. In cutting the open work out it is best to drill holes around the edges of parts to be cut, then using a chisel and hammer. Cutting on the metal with a chisel without drilling

will stretch it in places so that the sheet will not be level. When all the parts are cut out the work is filed to fit the pattern. The plates are then made level by hammering them with a wooden mallet on a surface plate.

The angles are next made from the same size stock. They are cut longer than necessary and 1 in. wide. To bend them as shown at A they are caught in a vise between two pieces of flat iron, leaving one-half of their width above the edges of the pieces. They are bent to the proper angle by hammering. The holes are next drilled with a $\frac{1}{8}$-in. drill. The angles are then held in place on the corners of the shade, marking through the holes with an awl. The holes are then drilled and countersunk on the under side for the head of rivets. A rivet set is used on the outside. The top of the angle must start $\frac{3}{8}$ in. below the top of the shade, for the reason that the cap is to be riveted at the top of the shade and there must be a smooth place for it to fit on.

The cap is next made. The shape of the cap before forming is shown at B. It is heated, and $\frac{3}{8}$ in. of the edge is bent as shown by the dotted lines on the drawing. It may be bent over the edge of a square block that fits the hole in the anvil. The final fitting is done while the piece is cold by using the hammer and also filing the edges to fit against the top of the corner angles. After

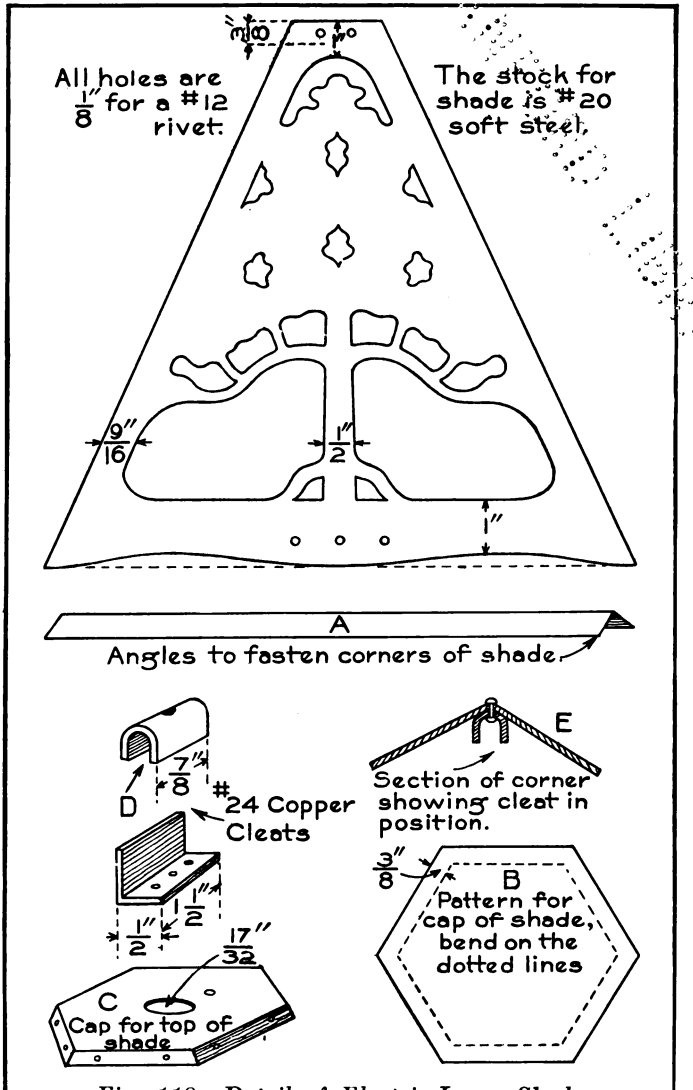

Fig. 118. Detail of Electric-Lamp Shade

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it is fitted holes are drilled for rivets. (See C.) The center hole is now drilled $\frac{17}{32}$ in.

Next the corner cleats to hold the glass are made as shown at D. The L-shaped piece is to be riveted at the bottom of each section. The U-shaped pieces are to be riveted in the corners as at E. There are to be two cleats for each corner. The shade is now smoothed with a fine file and emery cloth.

The lamp standard is next made. The drawings with dimensions are shown in Fig. 119. At A is shown the standard assembled. It consists of a $\frac{1}{2}$-in. steam pipe with coupling screwed on the top end. This coupling forms the fixture, which has three pieces of $\frac{1}{8}$-in. steam pipe screwed into it to hold the sockets. These pieces of pipe are threaded their entire length. Three $\frac{1}{8}$-in. holes are drilled into the coupling and tapped with a $\frac{1}{8}$-in. pipe tap. These holes are not drilled at right angles to the coupling, but on the angle as shown by the pipe nipples in the drawing. The three pieces of $\frac{1}{8}$-in. pipe are then screwed into the coupling, and the coupling screwed onto the pipe.

The top part of the standard is next made. This piece should be turned on a machine lathe, but it may be forged. To do this a piece of $\frac{5}{8}$-in. round iron is drawn a little on one end and driven into a piece of steam pipe a distance of $\frac{1}{2}$ in.

and welded. A collar is welded near the end, and the shank at the end swaged so a ½-in. thread may be cut for the nut. The piece is cut off, filed, and a thread cut on the pipe so it will screw into the coupling. The nut should be turned on a machine lathe, as it is round, but it may be forged on the end of a bar, cut off and finished with a file. The hole is drilled and tapped with a $\frac{17}{32}$-in. tap. The reason for this is that a loose thread will allow the nut to adjust itself to the top of the shade, especially if it is not tapped straight. A $\frac{3}{16}$-in. hole is drilled half way through the side of the nut to allow a little rod to be inserted to tighten it.

The base comes next in order. This should be a plate of soft steel ⅛ in. thick. It is hammered on the wooden block to raise the center part. A hole is drilled in the center and tapped for the lower end of the pipe. A hole is also drilled and tapped for a hard-rubber bushing. This is for the wire to go through and connect with the fixture.

After the pipe is screwed into the base the braces shown at B are forged and drilled. To fasten them to the standard two of them, on opposite sides of the pipe, are fastened in position with a small clamp. The holes through the base are now drilled and the braces riveted to the base with ¼-in. rivets. Holes are next drilled through the

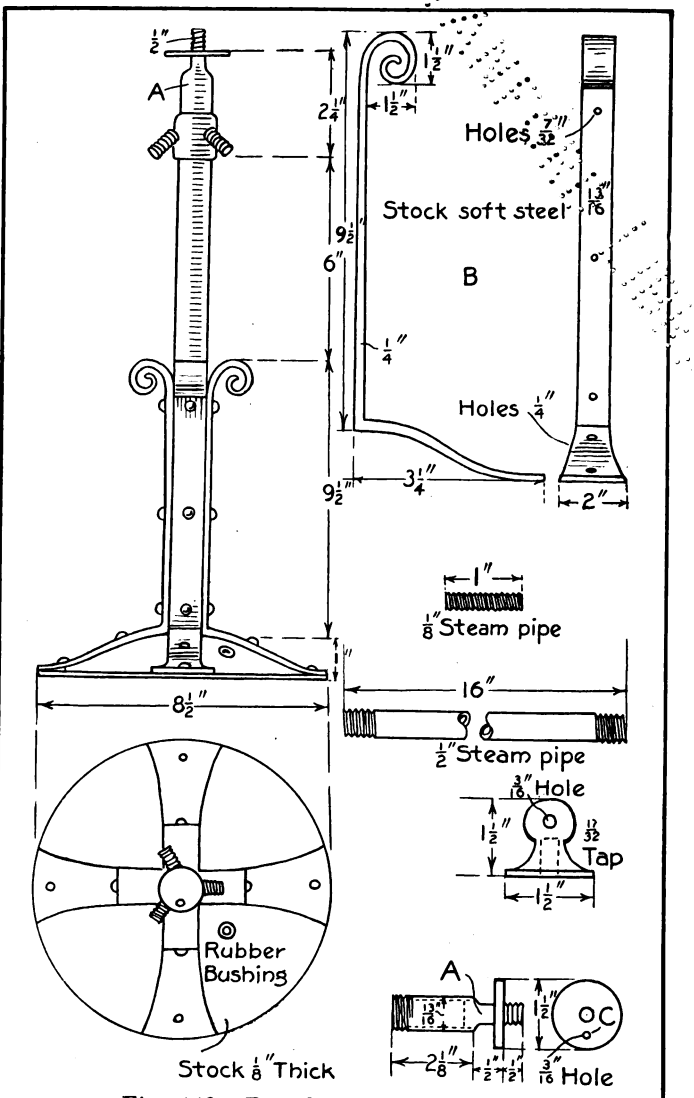

Fig. 119. Detail of Lamp Standard

pipe with a $\frac{7}{32}$-in. drill and tapped with a $\frac{1}{4}$-in. tap. A $\frac{1}{2}$-in. rod is now run through the pipe. Screws are run in the holes onto the rod and cut off long enough to rivet. They are riveted with a set in the vise and one on the rivet directly over

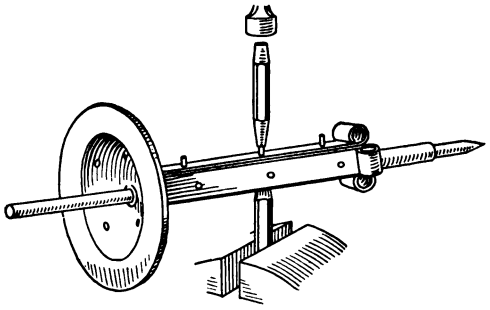

Fig. 120. Riveting the Braces

it, as shown in Fig. 120. When the rivets are all hammered down with a round head the other two braces are fastened and the $\frac{1}{2}$-in. round rod taken out of the pipe. The standard is now smoothed with a file and emery cloth and finished by burning oil on it.

The shade is now set on the standard. A center punch is set on the cap directly over the hole in the top piece, and it is given a blow with a hammer to force the metal into it. This will allow the shade to go onto the standard at the same place each time it is taken off and put on. The hole in the top of the standard is shown at C in Fig. 119.

The lamp standard is now wired, and when this is done the top part of the standard is screwed into the top part of the fixture, drawing it tight with a pipe wrench. The shade is now set in posi-

Fig. 121. Lamp with Shade of Twelve Sections

tion on the standard and leveled so that it will not lean one way or the other. This is done by bending the cap up or down as needed. The glass is cut for each section, and the copper cleats bent over it.

A lamp with a twelve-section shade is shown in Fig. 121. The cap at the top of the shade is round

except where it joins the sections of the shade. It is pierced on the sides to allow the heat to escape, as there are four lights under the shade. The rivets that fasten the angles in place are smooth,

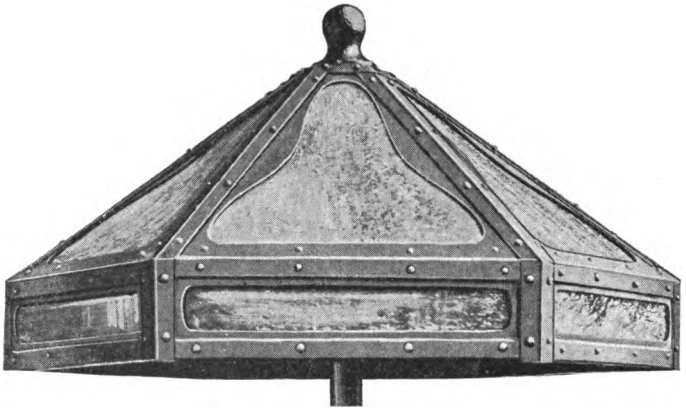

Fig. 122. Shade with Drop Sides

the holes in the angles being countersunk. The stock for angles is No. 18, while the sections of the shade are No. 20. As there is no pierced work in the shade the angles are made from heavier stock, adding strength to the shade.

Fig. 122 shows another kind of lamp shade, with drop sides. The sections and sides are of one piece of stock. The corners are fastened in the same manner as previously explained. Copper cleats are used to fasten the glass.

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